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EDITORIALS.

The Princeton Meeting.—The action of the Council in selecting next year's meeting place early has made it possible to lay out a comprehensive program of entertainment and papers thus early in the year. The conditions at Princeton are ideal for the meeting and the tentative selection of dates at the extreme end of June will result in the avoidance of conflicts with the dates of meeting of other societies. The Program Committee plans to consider all interests represented in the membership as indicated in the preliminary outline program which will be announced in the January BULLETIN.

The Thesis Problem.—This expression may be taken to mean either the subject matter of the thesis or the thesis itself. The Society has both in mind. In the first place, shall the thesis be practically abolished by making it optional or not? Some institutions, by their actions, say "yes," others, "no." The fundamental theory of the thesis all agree on, namely that a student is benefited, to a greater or less extent, by working on a problem of his own choosing and under the stimulus of his own initiative. The objections to the thesis, mainly in large schools, is the difficulty of properly supervising this work. If a thesis subject is a good one it is apt to absorb too much interest and time on the student's part. If otherwise it is of little use to him. He needs assistance in selecting his problem and in solving it. This requires a great deal of the instructor's time. A thesis should anticipate the problems of engineering life. There is great value in doing something not in the curriculum which enables a student to connect up with his engineering future. That thesis work has not been altogether a success is due largely to attempting to do too much, as Professor Hibbard pointed out in his Minneapolis paper. In some form the thesis must stay. The present reaction against it is due to lack of wisdom in administering it. This year's discussion by the Society should largely clarify the situation.

The Plan and Scope of the Bulletin.—The BULLETIN has now reached the stage of the established magazine in which it can readily obtain more contributions than it can publish and even now it is fifty per cent. larger than was originally intended. The aim of the Publication Committee is to print what the members want. The question is, do the members read the BULLETIN? If not it does not meet the need no matter how much the articles are admired. In response to a recent request for suggestions a number of constructive criticisms were received. A large number of members approve the present publishing plan of the Committee. But is there enough "ginger" in the reading matter? It does not call out the discussion that the Committee would like. What can we do to stir things up?

ASSISTANCE WANTED BY THE COMMITTEE ON COÖPERATION IN CIVIL ENGINEERING INSTRUCTION.

At the annual convention held in Boston in June, 1912, a committee on "coöperation in civil engineering instruction" was appointed. The object of this committee is to preserve the results of the symposium on civil engineering laboratory work which was held at the Boston meeting. A great deal of material has been received but more is needed. In order to present the final report in June next the Committee wishes the coöperation of professors and instructors who are engaged in civil-engineering laboratory work. The most definite way to get help is to ask members to send answers to the following questions, to the chairman of the Committee, F. P. McKibben, Lehigh University, South Bethlehem, Pa.

GENERAL.

1. How many hours are scheduled in one exercise for each of the following laboratory periods: (*a*) Materials testing, (*b*) hydraulic, (*c*) cement and concrete, (*d*) road materials.

2. Does the schedule time include the test only or does it allow the student time to work up the test during the exercise?

3. Does the student work up his reports at home or under the guidance of an instructor?

4. What preliminary study or preparation is required for each laboratory period before the student enters the exercise? If the student is required to read references, how do you insure that he performs this duty before entering the laboratory?

5. As preparation for a test, do you consider it good practice to require a student to read references before the exercise and to submit, when he enters the laboratory, a written report on what he has read?

6. Are your laboratory exercises in a subject given simultaneously with the class-room work of that subject, or are the laboratory exercises given after the student has completed the course in the class-room? Please tell me which you think is the better method.

7. What is the amount of fee charged each undergraduate student in each of the four laboratory courses indicated in question No. 1?

CIVIL ENGINEERING MATERIALS-TESTING LABORATORIES.

1. How many exercises do you give in your materials testing laboratory? In what year?

2. Please give a list of tests made at each exercise of this course.

3. Do you supply students with blank forms to be used at these exercises; if so, please send a set of these forms in the order in which they are used in the course. Also please send any preliminary instruction sheets used for each laboratory period. Also send photographs and drawings of testing devices other than ordinary testing machines; for example, of tools for shearing of metal or of wood; of devices for holding ends of wooden or metal columns to secure either concentric or eccentric loads; of instruments for fiber deformations of wood, steel or concrete beams; of instruments for measuring longi-

tudinal deformations of columns or tension specimens and of transverse deformations of columns; of instruments for measuring vertical deflections of beams.

4. In comparing computed and observed center deflection of beams, do you take account of the shearing deflection?

5. Have you used any mirror extensometers? If so, please send drawings and photographs with sample log sheets for their use. Have they proven satisfactory?

6. Do you give any vibratory or any impact tests for undergraduate work?

7. Do you consider these tests of much value for undergraduates?

8. What machines and what methods are used for making torsion tests? Any photographs or drawings of measuring devices for the same will be very useful; also sample of student's report or log sheet.

9. Have you put any new or unusual test into your undergraduate work recently?

10. Have you any new or contemplated device for testing or for reading deformations which would be of interest to other teachers of engineering?

11. Please send me a complete set of student laboratory reports in materials testing.

Hydraulic Laboratory.

1. How many exercises do you give in hydraulic laboratory? In what year?

2. Give a list of experiments made at each exercise of this course.

3. Do you supply students with blank forms to be used at each exercise; if so, send a set of these forms. Also please send any preliminary sheets for preparation used for each laboratory period. Also send photographs and drawings of any new or special apparatus of measuring devices for orifices, nozzles, meters, path of jet apparatus, water-motor tests, or pump tests.

4. Describe in detail methods of making turbine and water-wheel tests, with methods of measuring power by brake; also send detail log sheets and descriptions of any tests of electric motors used in connection with pump tests.

5. Do you have any filters for purifying water that are used for experimental purposes; if so, describe what you have and how used?

6. What is the total cost of such equipment?

7. Have you any new weirs or new methods of measuring the head on weirs?

8. What do you do to secure uniform pressure during tests?

9. Are your efforts satisfactory in this connection?

10. Have you any improvements to suggest to secure uniform heads?

11. Do you use mercury columns for reading pressures?

12. Have you trouble with corrosion of mercury in these glass tubes? Please send photographs or plans of mercurial gauges.

13. What do you do to overcome this corrosion?

14. What do you do to prevent blowing out of the mercury from pressure gauges?

Please send a complete set of student laboratory reports in hydraulic laboratory.

Cement Laboratory.

1. How many exercises do you give in your cement-testing laboratory? In what year?

2. Give a list of the tests made at each exercise of this course.

3. Does the student do any preliminary reading before entering these exercises; if so, from what books or pamphlets? If he is given preliminary instruction sheets will you please send me a set?

4. Do you test a standard cement of good quality only? What do you do to illustrate the defects in cement?

5. What specific gravity glass do you use?

6. Have you any good points to suggest in connection with the specific-gravity experiments as done by students?

7. How have you overcome troubles with the LaChatelier apparatus as to breakage or cleaning?

8. Have you tried the new ball-and-socket compression block for testing small cubes? Give experience.

9. Suggest any new tests or devices which you have tried or which you think would be useful.

10. Have you tried a simple experiment in which students make Portland cement by mixing the ingredients in proper proportions and burning and grinding same?

11. In this course are the students given the study of sand and stone; if so, what is done?

12. What tests of concrete do they make?

13. In concrete-beam work, what readings are taken?

14. Please send a complete set of student laboratory reports in cement laboratory.

Road Materials.

1. How many exercises do you give in your road-materials testing laboratory? In what year is this given?

2. Give a list of tests made at each exercise of this course.

3. Do you consider these tests of much value to the student?

4. Do you make any tests on bituminous materials; if so, please describe the apparatus used and show samples of the results obtained by students.

5. Can you suggest any improvements in existing road-materials testing machines or can you suggest any new tests?

Please send a complete set of student laboratory reports in road-materials testing laboratory.

The Committee will appreciate coöperation in making the report of real and permanent value to the members of the Society.

OTHER SOCIETIES.

The annual meeting of the **American Institute of Chemical Engineers** was held in New York City from December 10 to 13.

PUBLICATIONS RECEIVED.

The Pratt Institute publishes a weekly 4-p. *Students Bulletin* which gives in compact form the essential news of Institute activities and doings of the alumni.

Marquette University publishes a very attractive magazine, the *Journal*, the October number of which contains a revised list of the members of the faculties, notes on athletics and other college news.

The Targum, published by the students of Rutgers College, contains, in the issue of October 1, the first part of an important address by Howard Elting, President of the Chicago Association of Commerce, delivered at the dedication of the Commerce Building, at the University of Illinois. It is entitled, "The College Graduate a Business Tyro—a Matter of Adjustment."

The Valparaiso University Engineering Quarterly published in June contains articles on "The Erection of Structural Steel," by F. W. Dencer; "The Design and Detail of a Highway Bridge Abutment of Reinforced Concrete," by E. C. Earle and "The Construction of a Concrete Swimming Pool," by U. B. Hough. The articles are illustrated with problems and details of design.

Tulane University has issued a well-illustrated Bulletin giving in popular form an account of the work of the University. Special emphasis is laid on the value of a technical education.

Purdue University has issued a handsomely illustrated booklet containing views in many laboratories and elsewhere, giving an attractive picture of the work of the engineering departments.

The University of Maine issues a number of bulletins devoted to the work of various departments, including a general one giving pictures typical of the university work and photographs of the President and the Deans. Volume 20 of the *Prism*, the class book of the class of 1914, is a handsomely illustrated volume with pictures and "stunt write-ups" of the members of the class. The volume is sumptuously bound in leather.

The Polytechnic Engineer issued by the students of the Polytechnic Institute of Brooklyn contains, in Vol. 13, a number of interesting papers on technical subjects. Among these are a historical sketch of early

bridge building, and technical articles in civil, mechanical and electrical engineering. Professor W. D. Ennis gives an analysis of the cost of educating students in different technical schools, showing that, out of a dozen leading schools, only Cornell spends more on salaries per student, and that only slightly so. The number of students per instructor is a third lower at "Poly" than in any other school listed. Mr. H. W. Sheff gives a useful summary of the Brooklyn lectures delivered by Sir Wm. Ramsay.

The Société Genevoise has issued a small pamphlet, in English, describing high-power electro-magnets, including some wound with copper tubing for the circulation of cooling water.

The University of Illinois Engineering Experiment Station has a new bulletin, well illustrated, devoted to "The Strength of I-Beams in Flexure," by Professor H. F. Moore. This is a subject to which the Experiment Station has devoted much attention.

The Vanderbilt University Quarterly, No. 3, contains among other articles a full account of the commencement speeches; also much information regarding the work of the University.

Bulletin No. 466 of the University of Wisconsin contains the report of tests on reinforced concrete columns made in 1910 by Professor M. O. Withey. The Bulletin forms one of a series of researches in applied mechanics being conducted under the general direction of Professor E. R. Maurer. The price of the Bulletin is 40 cents. It contains 115 pages and is well illustrated.

University of South Dakota Bulletins contain well-illustrated descriptions of the campus and of student activities.

The Chicago Central Station Institute has issued a Bulletin describing its work in detail. This Institute has been formed to prepare young men for central-station work, and, in a way, it takes the place of the educational courses offered by manufacturers for young men intending to enter this line of work. The headquarters of the Institute are 112 West Adams St., Chicago, Ill.

The fifth edition of *The Determination of Time, Longitude, Latitude and Azimuth*, by Wm. Bowie, has been issued by the U. S. Coast and Geodetic Survey. This important book is fully reviewed in *Science* for October 10 by David Rines.

The Industrial Collegian, published by the students of the South Dakota State College, contains, in the issue for May 6, a chart showing the attendance at the college during the 28 years of its history.

The Congrès Mondial des Associations Internationales has published as pamphlet No. 11, a paper by Dr. E. L. Corthell, entitled "Suggestions

upon a Proposed International Association of Engineers." In 1895 Dr. Corthell presented to the A. S. C. E. a resumé of correspondence conducted with engineering societies with a view to establishing closer relations and based upon his proposition for an international society. He has consistently stood for such closer affiliation since that date and had hoped that something definite would be accomplished at the Congrès Mondial. He outlined a plan for a permanent International Engineering Congress such as has proved practicable in the cases of navigation and highway engineering. He desires that the Society for the Promotion of Engineering will further the plan.

PERSONALS.

Mr. H. Grattan Tyrrell, bridge engineer, of Chicago, gave an illustrated lecture on October 15, before the Engineering Society of Northwestern University on the subject of "Bridge Engineering." Mr. Tyrrell was formerly chief engineer for one of the Ohio bridge companies, and afterwards special bridge engineer for the Harriman Railroads in the western and Pacific states. He is author of several books on bridge and structural engineering.

Mr. Elwood Mead, the well-known irrigation expert, who has occupied educational positions and who has recently been chief of the U. S. Bureau of Irrigation Investigations, has been appointed head of the Division of Rural Institutions, a new department of the University of California.

The degree of doctor of laws has been conferred upon **Professor Mansfield Merriman** by Lehigh University. Professor Merriman was head of the department of civil engineering from 1878 to 1907.

THE NEW PRESIDENT OF DREXEL INSTITUTE.

The trustees of the Drexel Institute of Philadelphia have elected as President from December 1, Dr. Hollis Godfrey, now head of the gas bureau of the Department of Public Works of Philadelphia. He succeeds Dr. James MacAlister, who resigned as President last June, the position having been occupied temporarily by Mr. Horace Churchman, a member of

the board of trustees. Dr. Godfrey is by temperament and training an organizer who has made a study of management methods as applicable to education and who, at the same time, has a thorough knowledge and broad grasp of the problems of the manufacturer and the merchant.

Dr. Godfrey has recently made a careful study of the Drexel Institute; its equipment, its opportunities, its field, its potentialities, and its present and best possible future policy. This survey was made practicable through the coöperation of the city administration of Philadelphia in furtherance of its plans for the education of city employees. His final report, recently presented, has been accepted by the trustees of the Institute and its conclusions and recommendations were heartily approved.

As an educator Dr. Godfrey has had a varied and valuable experience. He organized the department of science in the High School of Practical Arts in Boston and for four years served as its head, a position, as stated recently by the then superintendent of Boston schools, "involving a new conception of science teaching and its relation to the prospective vocational employment of pupils. In this he was especially successful." He spent six years in night-school work in Boston in the same lines along which Drexel's evening work is progressing. With two other leaders in education, he organized the Garland School and for two years directed its policy in the teaching of science and in extension work. He served for three years as a member of the board of visitors of Tufts College and for two years as a member of the Alumni Council of the Massachusetts Institute of Technology. He has served as a lecturer and as a consultant in a number of educational institutions. He has published one book on sanitary engineering, "The Health of the City", which has been used by various universities, and two text books on chemistry used in a number of schools. Dr. Godfrey has had a part in the organization and control of three schools of domestic science for women and girls.

As a business man, Dr. Godfrey's conduct of the gas bureau, Department of Public Works, city of Philadelphia, is well known. He has spent over three years in actual shop work, holding every kind of a position from fireman to superintendent and receiving a thorough shop training and his industrial experience has been broad.

As a scholar it is perhaps enough to say that Dr. Godfrey studied at Tufts College, the Massachusetts Institute of Technology, and Harvard University, that he is a Fellow of the Royal Geographical Society, a member of Phi Beta Kappa, of the American Society of Mechanical Engineers, of the American Public Health Society (sanitary engineers), and of the Illuminating Engineering Society. He has published seven books and a number of monographs, and has to his credit important researches in pure and applied science either published or in preparation for publication.

Of the body of Dr. Godfrey's work as an engineer, it is of special interest in connection with Philadelphia to note that he was called in by Mayor Blankenburg at the beginning of his administration to make a study of the organization and operation of the water bureau, that he was called in to make a comprehensive lighting plan for Atlantic City, and that he is serving as consultant on the lighting restoration of Independence Square.

PROFESSOR THURSTON M. PHETTEPLACE.
1877–1913.

Thurston M. Phetteplace was born May 3, 1877. He was educated at the English and classical high schools of Providence; and received from Brown University the degree of Ph.B. in 1899 and of M.E. in 1900. Columbia gave him the degree of A.M. in 1909. At the time of his death he was associate professor of mechanical engineering at Brown University. In connection with Professor Brooks and the writer he was engaged in consulting work under the firm name of Kenerson, Brooks and Phetteplace. His speciality was automobile construction and gas-engine design. He was a member of Phi Beta Kappa, Sigma Xi and the following societies and clubs: American Society of Mechanical Engineers; Society for the Promotion of Engineering Education; Providence Association of Mechanical Engineers, of which he was President; University Club; Flat River Club; Providence Art Club; Swastika Canoe Club; Edgewood Tennis Club; and the Phi Delta Theta Fraternity. He had contributed to the technical press, and to the Proceedings of the American Society of Mechanical Engineers.

His genial disposition endeared him to a large circle of friends and his sudden death on September 7, following an operation for carbuncle, deprived the University of a very able teacher. W. H. KENERSON.

COLLEGE NEWS.

University of Birmingham.—Dr. F. C. Lee replaces Professor F. M. Dickson in the chair of civil engineering, while Professor P. F. Frankland succeeds Professor Dickson as dean of the faculty of science.

Brown University.—A very attractive program of lectures has been arranged. Of particular interest to engineers are

those on Electrical Engineering by Professor Watson and on Vocational Guidance by Mr. Meyer Bloomfield.—Mr. L. J. Bohl has been appointed instructor in civil engineering in place of Mr. R. E. Hutchins, resigned.

Clemson Agricultural College.—Mr. E. L. Shepard is this year taking the place of Professor F. R. I. Sweeny who is taking extra studies in civil engineering at the Rensselaer Polytechnic Institute.—Mr. W. W. Routten, formerly of the Mississippi A. & M. College, has been appointed head of the wood-shop in the place of Mr. A. B. Gardner, resigned. In the same division Mr. H. L. Pote replaces Mr. A. O. Horning. —Mr. S. R. Rhodes takes the place made vacant by the resignation of Professor W. C. Wagner of the department of mechanical and electrical engineering.

Colorado College.—Professor C. H. Goetze, formerly professor of forestry at The Ohio State University, has joined the faculty of this college.

Cornell College.—Professor Sylvester N. Williams, who for forty years has held the chair of engineering in this institution, retired from the active duties of his position, and was allowed his salary indefinitely as a token of appreciation of his services. Professor Williams is well known and respected in this and adjoining states for the careful manner in which he trained young men for engineering work.

Harvard University.—The American Academy has made a grant to Professor H. N. Davis for his researches in thermodynamics.—Professor Geo. F. Swain is giving a course to extend throughout the year, on the Physical Valuation of Public Service Corporations. It includes two regular lectures per week and one other at the option of the lecturer. This course deals with the physical valuation of public service corporations such as railroads, water works, gas and electric plants, etc., and its application in connection with rate making, taxation, capitalization, and expropriation. The principles apply to the appraisal of any industrial property, whether a

public utility or not, as, for instance, the valuation of industrial plants in connection with the issuance of securities. The problem is treated in its broadest aspects, and the historical development of the subject is outlined. A careful study is made of the various elements of the problem, such as original cost, depreciation, deferred returns, market value, going value and other intangible values, obsolescence, etc.; and reference is made to the reports of public service and other commissions dealing with this subject in various states.

University of Idaho.—The registration in the engineering college is 20 per cent. greater than last year.—Dean C. N. Little has been appointed a member of the State Highway Commission.—New appointments this fall include Professor M. F. Angell, in physics, and Professor Jesse Pierce, in mathematics.—Professor D. B. Steinman has been made professor of civil engineering. During the summer he was in charge of extensive improvements on the university campus, including the construction of a new athletic field.—Professor D. C. Livingston, of the mining department, has also been made a professor.

State University of Iowa.—Mr. Benjamin Bolt has been appointed instructor in descriptive geometry and drawing as has also Mr. R. E. Hutchins *vice* Mr. R. B. Dale resigned. The latter goes into mechanical engineering extension work of the Iowa State College. Mr. Hutchins was formerly with the State University of Iowa but for the last two years has been connected with the civil engineering department of Brown University.—Mr. D. P. Gilmore has been transferred from the department of descriptive geometry to that of engineering mechanics.—Mr. R. B. Kittredge has been appointed to the assistant professorship of railroad engineering.—The last legislature granted an appropriation of $25,000 for additional equipment for the college.

Johns Hopkins University.—The newly established department of engineering opened on October 7, with a most encour-

aging outlook. Sixty-three students altogether are enrolled in the department, of whom fifteen are college graduates. For the present school year the classes are being held in the rooms of the physical laboratory, through the courtesy of Professor J. S. Ames, the director. Work on the new engineering building at "Homewood," the future site of the University, is rapidly going forward; at the present writing nearly all the foundations are in and the completed structure is promised for next August, in ample time for the opening of the college year.—Professor John B. Whitehead, head of the department of electrical engineering, is secretary of the university committee on engineering studies.—Professors Carl C. Thomas and C. J. Tilden are heads of the departments of mechanical and civil engineering, respectively.

Kansas State Agricultural College.—Professor A. A. Potter, of the steam and gas engineering department, has been appointed to act as temporary dean of the division of mechanic arts to fill the vacancy made by the resignation of Dean E. B. McCormick, who left this institution in August to take up his work with the Office of Public Roads in the Department of Agriculture, Washington, D. C.

McGill University.—Mr. W. C. Willard, recently of Lehigh University, has been appointed assistant professor of railway engineering.

Michigan Agricultural College.—The year starts with a gain in enrollment of more than 300 and the prospect of a large increase in financial resources, the total estimated income being nearly $560,000. The enrollment for the year is nearly 1,550.

University of Minnesota.—Dean F. C. Shenehon is actively engaged this fall as engineering counsel for the government in the Chicago Drainage-Canal Suit.—Professor F. M. Mann is now in active charge in the department of architecture and comes to this position from a similar one at the University of Illinois. Mr. R. C. Jones, now doing special work at the Uni-

versity of Pennsylvania, will take up his duties as instructor in the department on January 1.—In the department of engineering mathematics Dr. W. L. Miser becomes instructor in place of Mr. R. W. Brink.—Professor J. P. J. Williams, formerly of Columbia University, takes the place vacated by Professor John I. Parcel, who is now at the University of Illinois. —Professor F. H. Bass has been active this fall in reading professional papers at the meetings of the American Society of Heating and Ventilating Engineers, The International Congress of School Hygiene and the American Health Association. —University extension work has been actively taken up this fall, courses being given in automobile construction, architectural history and design, reinforced concrete and many other useful subjects.—Professor B. L. Newkirk has appeared on the extension programs with illustrated lectures on the gyroscope and its applications.—The electrical engineering department will erect a large steel tower and wireless station.—Dr. C. W. Benton, head of the department of language and literature, has suffered a severe attack of paralysis and Professor C. M. Andrist has been temporarily appointed in his place.

University of Missouri.—Professor D. Copeland will spend this year on leave of absence in visiting mining regions of South America. While at Llallagua, Bolivia, he will superintend some experimental work in the treatment of tin ores.—The library has been moved into a new $60,000 fireproof building completed this summer.—A $70,000 gymnasium will be built this year.—The increase in enrollment this fall is 8 per cent.

University of Nebraska.—During the past summer the department of agricultural engineering has added to its building equipment the old Horticulture Hall, which will be used for museum, drafting rooms, lecture rooms and offices.—Mr. E. E. Brackett becomes instructor in farm mechanics, farm machinery and farm motors.—During the past summer Mr. Ivan Wood, instructor in farm engineering, was engaged in practical work with a reclamation company in North Carolina,

while Professors Chase and Seaton assisted with the Winnipeg Motor Contest, as engineer in charge and assistant judge, respectively.

Ohio Northern University.—The construction of the $100,000 Lehr Memorial Building has been begun.—A campaign for a $200,000 endowment has been completed with $235,000 subscribed.—More than 300 students are enrolled in engineering and the work opens with an unprecedented enthusiasm. The freshmen enrollment is considerably over 100. The growth has necessitated the providing of increased facilities particularly in drafting rooms.—Dean T. J. Smull was the chief speaker at the opening meeting at the Society of Engineers, his subject being "The Personality of the Engineer and What it Stands for." The local branch of the A. I. E. E. is also thriving.—Professor D. D. Ewing's place has been filled by the appointment of Professor E. B. Thurston who is well fitted to continue the former's successful work.—The class of 1913 pledged nearly $15,000 for the endowment fund.

The Ohio State University.—During the summer, the trustees, upon the recommendation of the president, have made the following promotions: Charles St. John Chubb, Jr., C.E., to be professor of architecture; Dana James Demorest, B.Sc., to be professor of metallurgy; Harry Clifford Ramsower, B.Sc., to be professor of rural engineering; Carl Bertram Harrop, E.M., to be assistant professor of ceramic engineering; Aubrey Ingerson Brown, M.E., to be instructor in mechanical engineering.—Mr. Franklin Wales Marquis, M.E., of the University of Illinois, has been appointed professor of steam engineering to succeed Mr. E. A. Hitchcock, M.E., who resigned last spring to accept a position as sales engineer with E. W. Clark & Co.—The trustees created in June a new department with the title "Recreative and Competitive Athletics" and appointed Mr. L. W. St. John, of Ohio Wesleyan University, Mr. F. R. Castleman, of the University of Colorado, and Mr. J. M. Wilce, of the University of Wisconsin, to membership in this department with the rank of professor and seats in the

university faculty. This new departure suggests an entirely new point of view on the subject of physical education and athletics.—The enrollment of the College of Engineering on September 30, 1912, was 764 and for the year 1912–3 was 785; the registration of the university for 1912–3 was 3,969. The registration of the college of engineering on October 6, 1913, was 883, a gain of about 100 or 13 per cent. The locus of attendance has again started upwards and the low point in the curve, it is hoped, has been permanently passed, notwithstanding the great increase in the attendance on the four-year courses in the College of Agriculture.

University of Oklahoma.—The engineering college starts with the largest freshman class in its history.—Mr. F. L. Weaver and Mr. L. W. W. Morrow become instructors in civil engineering and electrical engineering, respectively.—A central power and heating plant for the University is now under construction. It will be attached to the engineering building and its equipment will add greatly to the laboratory facilities. The cost will be about $42,000. The surface tunnel system of steam lines is being used, the top of the tunnel being the side-walk.—An extension department is being developed in several lines this fall. It is expected that it will result in considerable increase in the registration of the College of Engineering.—The University enrollment this fall has increased more than a third and that of the College of Engineering more than 40 per cent.

The Universities of Paris and Nancy each receive a gift of $100,000 from Ernest Solvay, the discoverer of the well-known process for the manufacture of soda, who celebrated the fiftieth anniversary of the discovery by large gifts.

Pennsylvania State College.—The College, through the generous aid of the last legislature, has entered upon a systematic campaign by extending industrial education to bring it within the reach of all the people of the state. This work has received hearty coöperation in all the cities and towns where an effort has been made to establish classes. The most important

centers for this extension work in vocational education have been established in Philadelphia, Erie, Harrisburg, Williamsport, Allentown, Reading, York, Lancaster and Altoona. All engineering extension work is under the direction of Professor J. A. Moyer, head of the department of mechanical engineering.—The extension division has established, in coöperation with the State Department of Labor and Industries, a collection of safety devices and appliances. A large number of such devices and photographs illustrating safety methods have been received from manufacturers throughout the country. Some of the more important devices are, Norton safety grinding wheels, from the Norton Co., Worcester, Mass.; electrically operated models of safety wood-working machines, from the Oliver Machinery Co., Grand Rapids, Mich.; circular saw guards, from Zeiler and Nagel, Brooklyn, N. Y., and from the Tenn. Coal and Iron Co., Birmingham, Ala.; safety ladders, from the Detroit Manufacturing Co., Ambler, Pa.—The annual banquet of the electrical engineering society was attended by one hundred juniors and seniors in electrical engineering. President Sparks, Dean Walker, Dean Homes, Dean Kinsloe and other speakers took part.

University of Pittsburgh.—The attendance in engineering shows an increase of over 30 per cent.—The Mellon Institute of Industrial Research and Specific Industries, for which Messrs. R. B. Mellon and A. W. Mellon gave the University the sum of $450,000 for building and equipment, has the foundation for a building completed and the construction will be rapidly pushed. Professor Robert K. Duncan, director of this department, has under him thirty fellows working on industrial problems. The Institute has recently issued a bulletin on smoke and smoke prevention, this being the first of a series of bulletins on this matter which will be issued by the University.—The school of mines is preparing to extend its extension work in the mining districts of Western Pennsylvania. This is being carried on by men who devote their entire time to the work. The school of engineering is undertaking extension

work for the first time in its history.—Professor George W. Case, of Purdue University, has been elected to the position of assistant professor of sanitary engineering with Professor Morris Knowles. One of the duties of Professor Case will be the planning of the new hydraulic laboratory which will be supplied with facilities for securing direct water head of 300 feet.

Pratt Institute.—Nine students started in the Westinghouse apprentice courses this fall.—On October 24, the second-year class in applied electricity entertained the first-year class of the same course at the Pratt Club. A large number of instructors of first and second-year classes were present and were called upon for short talks.

South Dakota State College.—Professor A. J. Willis, formerly of Cooper Union, is now professor of civil engineering, succeeding Dr. H. M. Derr who last year was appointed state engineer of South Dakota.—Growth of the university buildings has necessitated the reconstruction and extension of the general heating and lighting plant. The lighting system has been practically made over and changed from a d. c. to an a. c. polyphase system. The designs for the new system were made as a part of the regular work of the electrical seniors last year. The students also have done much of the installation of new apparatus and transmission lines.

Stevens Institute of Technology.—At a recent meeting of the faculty it was decided to admit graduates of accredited high schools to the freshman class.—Mr. L. A. Hazeltine has been advanced to the rank of assistant professor in electrical engineering.

Syracuse University.—Professor E. E. Lawton, formerly of the physics department of Denison University, has joined the electrical engineering staff as associate to Dean Graham.

Texas A. & M. College.—The mechanical and electrical students societies have opened up their work with great enthusiasm. The latter holds weekly meetings.

Throop College of Technology.—The third year of the Col-

lege opens with twice the number of students registered three years ago. Rigid entrance requirements are maintained, resulting in the rejection of more applicants each year than are admitted.—The students were addressed this fall by Dr. H. S. Carhart, research associate in physics. Two new professors were present at the opening, Franklin Thomas of the department of civil engineering and H. J. Lucas of the department of chemistry.—Dr. A. A. Noyes of the M. I. T. will spend several months at the College during the present year as professor of general chemistry. This is possible by a special arrangement made with the M. I. T.—A new chemistry building will be begun within the current year.

Union College.—Owing to the changes in the organization of the electrical engineering department previously announced in the BULLETIN the work of the department has been rearranged. Dr. Berg is giving a course of graduate lectures to twenty-two regularly enrolled students.—Mr. E. S. Lee has been appointed an instructor in electrical engineering.—During the past summer the laboratory has been greatly improved by the addition of considerable new apparatus, including a complete shop equipment for the use of students and the maintenance of the laboratory.

University of Utah.—The new administration building, to cost $300,000, is nearing completion. It is built of white stone with granite foundation and is fireproof. The administrative offices as well as the library will be located in it.—The last session of the legislature created a department of metallurgical research as a department of the Utah Engineering Experiment Station, connected with the school of mines, and located at the University. An annual appropriation of $7,500 is made to the station for research work in metallurgy. The chief in charge of this work will be appointed by the director of the Bureau of Mines at Washington, D. C. He will have charge of the research fellows who are working in the department of metallurgical research. There are at present five such fellows.

COÖRDINATING COMMITTEES.

BY SAMUEL C. EARLE,
Professor of English, Tufts College.

In some engineering schools little is done to bring the work of the different departments into more than external relations; in others continual efforts are made to keep all the subjects so closely correlated as to form a single carefully-organized process of instruction. To those who are working out schemes of coördination a means that has been tried in the Tufts College engineering school may be of interest.

Standing Committee on Correlation.

The first step was the appointment of a standing committee, consisting of all those giving instruction to freshmen, to work out the most efficient correlation of the first year's work. The members have met as a committee of the whole and as two subcommittees, one including all those who give instruction during the first semester, the other those who give instruction during the second semester. The work of each half year has been studied while it was carried on with a view to remedying defects at once if possible but more particularly for the purpose of crystallizing present experience for the more effective organization of the work for the future.

Methods of Operation.

Two methods of study have been found serviceable. (1) Each department was required to present an outline of its work for each week of the semester. These outlines were studied by the various members of the committee in order to discover ways of fitting together the instruction in the various subjects so as to form for the student the most effective single course. The result was the immediate meeting of a number of

formal or informal subcommittes consisting of instructors in two or three departments to bring about improvements which seemed obvious the moment they were thus suggested. So much of value has been accomplished in this way that the departments have been asked to prepare another study of their work which will show more definitely the immediate and the ultimate objects sought in the instruction. (2) Each member has been given opportunity to bring up any question of educational or disciplinary policy which he wishes discussed or on which he considers it advisable to have concerted action. The following subjects, from those already discussed, will indicate more definitely the character of this part of the work.

The omission of units in writing denominate numbers; standardization of terms; computations; measurements; the use of the calculus.

Neatness; exactness; the use of scrap paper.

Attendance; tardiness; appearance in class; attention to work in class; time spent on the various subjects outside of class.

Examinations.

Development of student interest in the profession and in general education.

Nearly all of the matters that have been presented to the committee so far, and most of those that would naturally come before such a committee, are so distinctly questions of attitude or of inner organization of the classes that action does not require the sanction of the faculty. In cases where the committee has not full power, the question is debated and a conclusion is reached which is referred to the proper authority with the recommendation of the committee.

A committee consisting of *all* of the instructors for a single semester, in spite of the danger of unwieldiness, has been found more effective than a smaller committee no matter how much care were taken to make such committee representative.

The most important field for coördinating work is in the freshman year, and a committee to perform this task should serve year after year. Naturally the problem becomes more complicated with the increase in the amount of election allowed. At Tufts a committee similar to the one for the

freshman year is to be appointed to carry the work into the sophomore year, and when that is well under way similar committees will probably be appointed for the junior and senior years.

Results Obtained.

The results obtained so far seem to show that such committees can be serviceable in the following ways:

1. They will discover and remedy various minor but important instances of lack of efficient adjustment in the instruction.
2. They will save the students now and then from the confusion and possible irritation that may arise when different instructors unwittingly give conflicting instruction.
3. They will make more probable the early discovery of student cases which become serious simply because they are not considered in time.
4. They will help each instructor to see the course as a broad process of education and thus enable him to keep his special work in a truer relation to the whole.
5. They will give each instructor the opportunity of getting frank and sympathetic criticism from many others.
6. They will furnish one of the best means of enabling the older teachers to get new suggestions from younger men, and of introducing new instructors to the aims and methods of the school and to the experience of their elders.
7. They will make possible the discussion of educational problems for which routine work leaves little time in the faculty meetings or elsewhere.

MASS AND WEIGHT IN ELEMENTARY MECHANICS.

BY H. M. DADOURIAN,

Instructor in Physics, Yale University.

In the June number of the BULLETIN OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION, Professor Edward V. Huntington discusses the difficulties which the student of elementary mechanics encounters in trying to grasp the ideas of force, mass and weight; and makes a number of recommendations intended to remove these difficulties. No teacher of elementary mechanics will deny the existence of the difficulties, but it is doubtful if any considerable number of them will support Professor Huntington either in his diagnosis or his proposed remedy.

The difficulties which the beginner encounters in his study of mechanics may be divided into four classes. These are the difficulties which are due to (*a*) the intricacy of the new ideas introduced, (*b*) the multiplicity of the systems of units, (*c*) the ambiguous and equivocal use of some technical terms and (*d*) the lack of skill and aptitude to manipulate intelligently the mathematical tools which the student has at his disposal.

As the last source of difficulty does not come within the scope of the present paper I shall confine the discussion to the first three. Professor Huntington lumps together the three sources of difficulty and puts them at the door of the force equation $F = ma$. It would seem that an equation which has rendered such invaluable service to the engineer and to the physicist since the time of Galileo deserves a greater consideration. The force equation may be held responsible for difficulties of the first class but not for those of the other classes. The difficulties which the beginner encounters in dealing with

this equation do not have their origin in the form of the equation. They emanate from the new and intricate concepts involved in the magnitudes which the equation connects. They are due to the inherent complexities of the ideas of force, mass and acceleration.

In order to minimize the difficulties Professor Huntington proposes to write the force equation in the form of a proportion between two forces and two accelerations, $F/F' = A/A'$, and thus avoid the explicit appearance of mass in it. Professor Huntington's paper will give the casual reader the impression that he has entirely eliminated the idea of mass. As a matter of fact this is not the case. He does not propose to do away with mass. His scheme amounts to adopting time, length and force as the fundamental magnitudes instead of, as at present, time, length and mass. Such a change may simplify a few formulæ but it will certainly make dynamics a much more complicated subject than at present.

There are two questions which are, it seems to me, confused in Professor Huntington's paper; namely, the questions of the fundamental units and of the fundamental principle of dynamics. He observes, and with good reason, that the presence of such a difficult concept as that of mass in the fundamental equation of dynamics is unfortunate. He then proceeds to put the equation into a form which does not contain the mass explicitly, but in doing this he virtually replaces mass by force as one of the three fundamental units.

I believe that the same object can be attained more simply and effectively. The entire subject can be based upon a single fundamental principle involving only forces and their counterparts, that is, kinetic reactions. The explicit mention of mass can thus be avoided as can also that of acceleration. By clearing the principle from these two difficult dynamical concepts it is brought within the mental grasp of the beginner.

The difficulties which arise from multiplicity of sets of units are remedied best by discarding as many of these sets as is practicable. Professor Huntington's recommendations with

regard to discouraging the use of the terms "poundal," "gee-pound," "slug," etc., are to be commended.

The difficulties which are due to the equivocal use of words are not done away with by Professor Huntington's scheme. The confusion which arises in a student's mind in connection with the relation between mass and weight is due to the fact that the same term "pound" is used to denote the units of both magnitudes. The simplest and most direct way of eliminating this source of trouble is to give pound-mass and pound-weight two different and distinct names. The term *pound* and the symbol *Pd.* may be used to denote, exclusively, the *pound-mass;* on the other hand, *libra* and *lb.* may be used to denote the *pound-weight.* With these notations the student will have the simple and perfectly definite relation

$$1\ lb. = g.pd.$$

and will experience no difficulty in deciding upon the proper place of g in equations involving units of mass and of weight.

Recommendations.—It seems to me that the adoption of the following recommendations will eliminate most of the difficulties which the student and the instructor in mechanics usually encounters and which are not inherent to the subject.

I. State the fundamental principle of mechanics in a form which does not involve the concepts of mass and acceleration, explicitly.

II. Use the term "pound" to mean pound-mass only, with the abbreviation "pd."

III. Use the term "libra" to denote pound-weight only, with the abbreviation "lb." Thus 1 lb. = g.pd. = 32.2 pd.ft./sec.^{2}

IV. Discourage the use of the terms "poundal," "slug," "gee-pound," etc.

With the exception of the use of the term "libra," I have already adopted these recommendations in my classes.

PROFESSOR HUNTINGTON'S REPLY TO DR. DADOURIAN.

After a careful reading of Dr. Dadourian's criticism of my

paper entitled "Recommendations Concerning the Units of Force," I find that he ignores altogether my Recommendations Nos. 1, 2, 4 and 5, while he apparently agrees with Nos. 3 and 7. His criticisms are, therefore, directed wholly against Nos. 6 and 8.

(*a*) In my Recommendation No. 6, I urge the recognition of the well-known equation $F/F_1 = a/a_1$, or $F/W = a/g$, as the fundamental equation of dynamics. Dr. Dadourian proposes, in his Recommendation No. 1, substitute a new form of fundamental principle, which he believes to be simpler and more effective. The fact, however, that he does not attempt any concise formulation of his new principle, but merely refers the reader to the elaborate discussion in his recent textbook, may be taken as sufficient evidence that his method does not possess the simplicity which he claims for it. A close examination of his book will, I believe, confirm this opinion.

(*b*) In my No. 8, I recommend that whenever there is any possibility of confusion between the pound-force and the pound-mass (or between the kilogram-force and the kilogram-mass), these terms be written out in full. In place of this recommendation Dr. Dadourian proposes (see his Nos. II and III) to restrict the term *pound* to mean "pound-mass," and to introduce the term *"libra"* to denote "pound-weight." In my opinion, the attempt to introduce any such restrictions or modifications in well-established terminology is absolutely futile; and any attempt to insist upon such violations of language in the class-room serves merely to insulate the student from the great current of the world's thought. (Notice also that Dr. Dadourian's recommendation applies only to the *pound;* he has nothing to suggest in regard to the *kilogram.*) My Recommendation 8, on the other hand, recognizes existing facts and makes the best of them. As I point out, however, the confusion in question will not occur if the equation $F/W = a/g$ is taken as fundamental; for only forces, not masses, appear in this equation. There is certainly no confusion, but rather a great and well-recognized convenience, in

the fact that the force exerted by gravity on a pound-mass, in the standard locality, is precisely one pound of force. What has Dr. Dadourian to offer that is simpler than this?

In conclusion, permit me to point out that my paper was concerned primarily with the units of force, and did not attempt to dogmatize in any way upon the vexed questions connected with mass. Indeed, if all my eight recommendations should be universally adopted, every teacher would still be at liberty to introduce the concept of mass, *later on,* in any way that seemed to him good, or to omit it altogether if he found that he could handle the all-important question of inertia sufficiently well without it. All that I assert in this connection is that the prevailing habit of introducing the difficult concept of mass *right at the start,* and thus making it, and the equation, $F = ma$, *fundamental,* is certain, as a matter of experience, to "bedevil" all the student's familiar and useful notions in regard to force and its measurement.

THE SKILLED WORKMAN.*

BY MILNOR ROBERTS,

Dean of the College of Mines, University of Washington.

The idea of a skilled workman appeals to most boys and young men especially to those of a mechanical turn of mind. How often as boys have we watched a mechanic lay out a piece of work, gather the necessary tools and materials, begin operations perhaps upon some small part for a use which we could not fathom, then take up other parts and finally fabricate the whole.

The child who is absorbed in watching a horseshoe beaten out on the anvil and fitted perfectly to the horse's hoof comes sooner or later to realize that a trained mind and a true eye guide the blows of the hammer. In a similar manner grown men stand on a city street watching the growth of a steel-framed building; some are attracted by the marvellous physical control and daring of the structural workers, others by the evidences of the designer's art which appear as the building progresses, while still others take particular interest in the craft of the builder in devising ways of carrying out the plans. Other instances of skill in dealing with mechanical things come to mind readily and are easily recognized. The usefulness of such skill is acknowledged and always is a subject of admiration.

Such operations as the writing of an opinion or the organization of a business enterprise stand on middle ground between the concrete and the abstract. Each is largely the work of a man's mind but nothing would result unless the thought were carried into effect, in the one case put into suitable language and in the other worked out in plans for business activity.

* An address delivered to the student Mines Society of the College of Mines, University of Washington.

The skilled workman in the purely abstract is often spoken of as a master mind. Material things may form the basis of his reasoning, as when Darwin bent his powers of observation to discovering the origin of species, or the grounds may be abstract, as in the case of constructive thinking in philosophy; but in both cases it is power of mind that brings results. Naturally, skill of this subtler kind is not as apparent as that exhibited in handling concrete things, in fact it may remain unrecognized until the completed work appears.

The skilled workman is not necessarily a person of great natural ability or of unusual talents. Doubtless the advantages of superior inherited powers will be apparent when other conditions are equal, but not every gifted person can fill the part of the skilled workman. The latter is rather the result of application and practice,—in a word, of training, whether received from others or self-applied. It is this very fact that makes the present subject of interest to students. You are here not only to study certain subjects but also to learn how to do technical work in a professional manner; and, more important still, to so school yourselves that you can use your powers to the utmost and do practically anything that lies within their actual limits. In this connection it is pleasant to remember the definition of genius as "the infinite capacity for taking pains," a concept that affords hope to those of us who are merely ordinary mortals.

The principles just stated may be applied directly to ourselves. Consider first the physical side of our training. The life of a mining engineer, particularly in the earlier years of practice, and of a metallurgist to a less extent, may require as much bodily as it does mental exertion. Indeed, one of the pleasantest features of our profession is the abundant opportunity it offers for the use of one's physical being. That being the case, it is important to keep in good physical condition and to be practiced in whatever tasks are likely to fall to us. To begin at the bottom, your first summer's job as an undergraduate is likely to be at some form of mine labor. Shovelling looks simple but is so important that it is now receiving

the careful attention of engineers. If "mucking" is one of your duties, by all means learn how to shovel in the best way from all positions, in order that you may know from experience when a laborer is doing his work properly and how much muck he should handle in a half-shift. If hand-drilling is to become a lost art, let us at least hand down the knack of sampling with a moil and single-jack.

Even in the matter of travel the advantages of knowing how are quite real. Once the railway is left behind, a man's own resources begin to tell. On the trail an experienced rider takes pleasure in traveling at the best speed his animals can maintain; at evening he is not over-wearied but is ready to collect his notes or investigate whatever of interest the camping locality affords. If one of our northern rivers is to be the highway most frequently used during an expedition, a man would be more independent and capable if he could himself pole a boat or run a riffle, not to mention the ability to swim ashore when that seems the proper move to make. No engineer need be a jack-of-all-trades, but a mining engineer encounters varied conditions and will derive both pleasure and satisfaction if he has trained to meet them. Many opportunities for physical training of a useful kind are open to a student; wrestling and tumbling may be practiced to produce strength and agility, while the athletic field and the various rough trips one makes in this region are excellent means of building up good wind and endurance.

Although experience is a great teacher, some of her courses are so long-drawn-out that a pupil might do well to take a little coaching on the side while waiting for her instruction. The question of equipment for a particular trip is doubtless determined best by experience, but forethought, inquiry and a study of the probable conditions prevailing in a region to be visited should result in a fairly good guess at the outfit required. One is morally bound to give as careful attention to such important details as to any other part of his services. To put it plainly, an engineer who goes out in the hills for a client without a reasonably suitable equipment is as unfair as

the plumber who answers a call to a distant part of town and on arrival there finds that he must return to his shop for a washer. Again, the engineer who puts no trust in notes, measurements and samples, but is confident of his ability to "see things and size them up,"—an attitude sometimes assumed to cover laziness or lack of knowledge,—forgets that his client is entitled to receive not only an opinion but also information which may be submitted to others for judgment.

If it is true that a workman is known by his tools, then a man who considers himself an expert is expected to have proper tools and to know how to use them. The tools of a field engineer are such minor matters as the means of travel he uses, his outfit, maps and instruments, which aid him in applying his knowledge of geology and ore deposits. For the organization of an enterprise a different kind of equipment is needed, namely, familiarity with the law, finance, management and labor. The running of a mine demands still other qualifications. If one's duties are varied, he will accumulate in course of time a chest full of tools whose handles he knows, while if he follows continually a single line he will be master of fewer pieces but their edges probably will be keener.

A distinction exists between receiving instruction in engineering subjects in college and the attainment of skill in applying them. It may be pointed out in passing that the difference between an engineering college and a training school is not always recognized by laymen and in consequence misunderstandings sometimes arise. Since the time within the college year that is available for actual practice is limited, skill is to be attained to a high degree only through seizing every opportunity that can be found for training one's self.

Mining is peculiarly an affair in which skill is highly rewarded while lack of it may be fatal to success. Mediocrity stands less chance here than in some other professions. For instance, in locating a line of railway a route may be selected that proves later to be an inferior one, but it serves in some fashion. A miner, however, as a general proposition is either

on his ore-body or *off* it. Georgius Agricola, writing in the sixteenth century, recognized this principle and stated it fully in his "De Re Metallica." I quote a characteristic statement in Book 1 of the recent Hoover translation:* "But persons who hold these views do not perceive how much a learned and experienced miner differs from one ignorant and unskilled in the art. The latter digs out the ore without any careful discrimination, while the former first assays and proves it, and when he finds the veins either too narrow and hard, or too wide and soft, he infers therefrom that these cannot be mined profitably, and so works only the approved ones. What wonder then if we find the incompetent miner suffers loss, while the competent one is rewarded by an abundant return from his mining?"

LYNN TURBINE RESEARCH DEPARTMENT OF THE GENERAL ELECTRIC COMPANY.

BY S. A. MOSS.

At the Lynn works of the General Electric Company a very large building is devoted to the manufacture of small sizes of steam turbines, from 5 kilowatts to 2,500 kilowatts capacity. This work is under the general supervision of Mr. Richard H. Rice. As an adjunct to this is a research department employing ten to twenty men in scientific work. This department has developed many new types of apparatus. In such work an experimental machine is built, tested, modified, and retested, and so on until a satisfactory performance is obtained. In this way a machine or member is brought into condition for commercial exploitation, after which it is given over to the commercial department. Similar work is done with indivdual parts of commercial machines so as to improve efficiency. Exhaustive work has been done on each of the elements of a steam turbine, so that the performance of a machine is readily

* Georgius Agricola, "De Re Metallica"; translated by H. C. Hoover and L. H. Hoover, London, 1912. Page 5.

known from synthesis of its elements. One important product is the present line of centrifugal compressors now built by the General Electric Company for compressing air to pressures of from 1 to 30 lbs. per sq. in. and various volumes up to 500,000 cu. ft. per minute. The work of the department is carried on largely by recent college graduates who serve an apprenticeship of a year or two for the sake of experience.

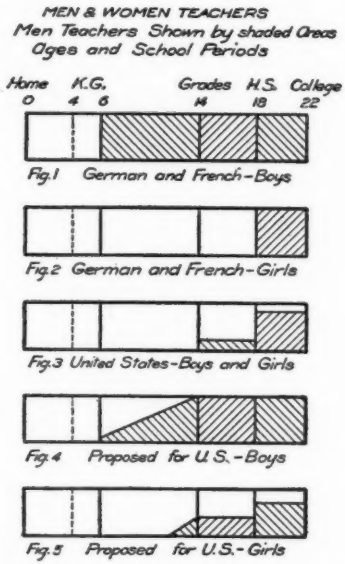
FUNDAMENTALS OF EDUCATION.

BY F. W. SPRINGER,

Professor of Electrical Engineering, The University of Minnesota.

Men and Women Teachers.

There is no evidence, either here or abroad, of any let up for some time in the movement toward vocational subjects, in fact, scientific progress promises more necessity for these subjects in the near future. We may then expect to see the



demand for vocational courses for boys result in masculinization of high schools and even the grade schools, since men can best train boys to become good home and nation providers.

There are two reasons for doing this, first, men are needed as teachers of vocational subjects, and, second, boys need a man's example, and a man's viewpoint in quite a large part of even grade subjects. No matter how hard the best woman teacher may try, she cannot set a man's example, and certainly her precepts and more or less empirical instruction cannot equal the combined example and instruction of an equally good man teacher.

In the accompanying diagrams, the shaded areas indicate men teachers and the clear areas women teachers. These diagrams show up one very remarkable fact—*our boys have about the same relative number of women and men teachers as do German and French girls.*

Figures 4 and 5 are proposed as the probable result of our present tendency toward masculinization.

As indicated by Figure 4 above, at least one man teacher is supplied for boys beginning at the age of six, to supervise playground sports, gymnasium work, athletics, scouting, drill, school political organizations, selection of leaders, in order to bring out the elements of citizenship. In addition, since boys are curious to know about many things, some *man* should be around who can tell them the things they should know, when they want to know them. This teacher should be a young man who has had a wide academic training and some athletic and military drill. In other words, he should be a boy's man. This is a very difficult position to fill.

Manual training, suited to the play period of a boy's life, beginning at the age of ten, should be taught also by a boy's man who has had a good engineering training and some shop experience.

The manual training, such as that leading to serious trades, may begin between twelve and fourteen, and continue till eighteen. These latter courses should be taught *only* by men over thirty years of age who have had much real shop experience, together with some pedagogical training. A college manual training course does not appear to be sufficient preparation for such a position.

Since the best way to learn a real trade is to work at the trade under the conditions of the actual practice of the trade, we may expect to soon see American boys of fourteen to eighteen working at their trades as apprentices and taking supplementary "Fortbildung" school work in industrial high schools in order to learn the theories and science of their calling, and to acquire an education in good citizenship and hygiene. This training will not only make them adaptable to their present vocational and citizenship environment, but will prepare them for the *inevitable* future changes in their respective trades.

Owing to the fact that trade schools are in general expensive, and, also because they lack the human, commercial, and physical environment necessary to really learn a trade, we may expect to see the combination of fortbildung schools and shop apprenticeships, and shop or factory trade schools displace the city-maintained trade schools to a large extent.

The coming industrial high school graduates will undoubtedly drive out the college engineering graduates from many of their present fields, and force them to take up the more advanced work. This has already happened in Germany. Taken as a whole, the result will be a strengthening of the college of engineering because of the necessity for it, and we shall, undoubtedly, soon see much of the engineering-educational practice work, which is used to illustrate the application of theories, sifted, re-paralled and re-sequenced.

College engineering courses will turn out a better product, first, because of the industrial high school preliminary training, and second, because of the stimulus of research work, in the upper years, which will, no doubt, soon be more common.

At the present time, a boy who decides at the age of fourteen, or in his first high school year, that he is to be an engineer, has no real engineering contact till the latter part of his college course. In other words, his sphere of knowledge, while perhaps expanding in other directions, does not increase in an engineering direction during a period of from four to six

years. This fault is common in most of the present engineering schools the world over.

The attempt now made to compensate for this flat spot on the sphere of engineering education in high schools and engineering colleges by teaching certain cultural and theoretical courses in a theoretical way gives, of course, unsatisfactory results.

In many cases, these cultural, or so-called mental-training courses correspond to a slender structure, started upon the sphere of knowledge of a student, and built straight out and away from the student's sphere of activities. He is expected to use the information in these courses when his sphere of activity has been expanded later by actual contact with life.

Even in college courses, students are required to "learn" much that they have no opportunity to apply and have no immediate use for, and much which the great majority will never use. These courses are taught principally because of the mental training they give. This alone ought not to be a sufficient reason for them since every theory and principle should be clinched by repeated applications which, at least, approximate the conditions of real life.

Engineering education, as well as education in general, will never be satisfactory until that method is adopted which will cause a boy's sphere of real knowledge to expand from birth by his working into his every-day life the ideas received in the successive steps of his development. This would enable him to build up a structure during the school life sufficiently solid to carry the load of mature knowledge.

At the present time, a boy on leaving school finds that he has no place to put the knowledge acquired by experience, except upon a school sphere of ideas. He is thus compelled to reconstruct his sphere. We call this the orientation of practical life. There should be no necessity for much orientation in beginning the life work, nor should there be the present random search for suitable spheres of action, or careers.

A rational system of education would help matters very

much in that pupils would show their natural tendencies while young. Under the present system, special talents are leveled to sameness until the orienting period after graduation.

Careers.

The subject of career selection is a very complicated one and cannot be entirely settled by the adoption of a rational system of teaching.

The modern tendency is to increase the volume output per day, per man, by the use of highly specialized processes, which at the same time reduces the variety per man. This results in a demand for two kinds of experts,—leaders and workmen. The former require a broad horizon and an exacting knowledge of details, while the workers need very great skill and speed in a small range of operations.

At the present time it would seem that the school systems were arranged to produce leaders rather than workers, on the theory that there is a chance for every boy to become president or governor or manager. Of course, this attitude must sooner or later be abandoned, and most boys will be trained to be workers, with a provision for selecting those having the ability and other characteristics fitting them to be leaders.

The problem of training the workers for their trades, etc., and giving them in addition a proper "sense of state," is not so very difficult except as to the selection of the trade or career. As proven by experience, the leaders should, in general, be selected, as by examination, from the workers, and then provided, if necessary, with the means for further preparation. The problem hinges on starting along the right line for the particular individual so that use may be made of his hereditary aptitude or fitness. There is little use in trying to make a lawyer out of a boy with only brains enough to guide a wheelbarrow, or to make a millwright out of a boy who is not strong enough to drive a tack.

Individual teachers are not generally competent to select careers for pupils; neither is the average boy, without advice.

Parents, for various reasons, very often fail in this matter when they, above all others, except the boy himself, want to be right. In general, there is today neither a real system for assisting boys to select careers, nor is there suitable training for preparing the mass of boys for trades or careers. The factors involved in this problem may be outlined as follows:

1. Introduction of a rational system of education in the grade schools, which would allow more development of the boys as individuals than at present and which would allow special hereditary abilities and tendencies to be made use of.
2. Introduction of certain courses directly preparing boys for usefulness in particular spheres of action and thus eliminating much of the orientation now necessary at seventeen or eighteen, after graduation.
3. Tentative selection of a career for a particular boy, based upon:
   (*a*) Local conditions, opportunities and probable demands, and similar considerations involving larger fields.
   (*b*) Parental desire and ability to create opportunities for their children.
   (*c*) School reports,—past records in school and school community. Teachers' "size up" and school tests.
   (*d*) Health and physical strength of the pupil as shown by reports of physicians and specialists, as of the eye, ear, nose and throat, dentists and athletic directors.
   (*e*) Hereditary traits, both mental and physical, and probable tendency as determined by tests of the susceptibility of the senses to stimuli, and characterization based upon cranial, facial and physical measurements.
4. Trial in a proper environment as determined by consultation based upon the above, and as indicated by the wishes of the pupil. It would, of course, be the duty

of advisers to divert the boy from those pursuits for which he was physically or mentally unfit. For example, a weakling with weak lungs should not follow a calling involving conditions unfavorable even to healthy lungs.

There is no question but that some useful field could be found for nearly every pupil; and the best possible done with the poorest material, in the interest of the present racial efficiency. In the interest of future efficiency, however, a report should be made of the defects found in pupils and their causes noted for the advancement of rational eugenics.

A beginning has already been made in some cities along these lines.

Educators.

It is believed that the teachers, principals, superintendents and school directors constitute about the most important factor connected with school education, second perhaps only to the ideals of the race. It is believed that the greatest single problem of all, connected with education, is in inducing men and women of the right caliber, personality and training to take up educational work and especially the new subjects and lines of work to be begun in the immediate future and for which there is now a pressing need. If the right personnel could be obtained, it would seem that most of the educational problems could be solved by those in charge as the problems arose.

There is but one way to induce the right kind of young people to enter this work, and that is by offering such salaries and other inducements that high-class candidates will go to the expense of training and run the risk of competing for positions. Career selection applies to teaching as well as to other vocations.

The *school problem* should, in general, be studied from the bottom to the top by those with a wide knowledge of life and an outlook upon the future. Changes in the school system must be made, however, beginning at the top by preparing

suitable teachers for the work at the bottom. It is to be regretted that there is not a competent, paid, *national committee of educators* to conduct a continued investigation of the school problems and to collect, digest and distribute literature on the subject to interest and *educate the public* as well as the teachers.

School Trend.

As to the probable changes in our schools, it would seem, judging from present tendencies, and from the experience of Germany in particular, that our school system will be modified as follows:

1. Masculinization in the high schools, and also to some extent in the grades.
2. Establishment of schools, or courses, for training vocational men teachers for boys in high schools and in the grades. Provision for developing college engineering teachers.
3. Introduction of a system of career selection.
4. Partial co-educational segregation on a vocational basis and also vocational class segregation.
5. Compulsory vocational and citizenship training for the masses of students between fourteen and eighteen years of age. Fortbildung schools, with evening courses, cultural evening lectures, and night schools for irregular students.
6. State, city and private trade schools to suit particular community needs.
7. Factory and shop trade-schools, supported by manufacturers in the factories with sandwiched or coördinated shop and class work.
8. A sharp differentiation between manual training, or vocational culture, and trade-school work.
9. Reduction in the number of distinct courses taught at one time to a student, and a reduction in the amount of subject matter taught, with more and immediate applications of theories, especially in the grades.
10. Sifting of theories and subject matter now taught in many grades and classes together with a re-sequencing and

re-paralleling of courses, and accompanied by greater instructor coöperation.

11. Disciplinary or military training in some form, in both high schools and grade schools.

12. Citizenship and hygiene training, beginning very young, as incidental work.

13. College engineering courses arranged to receive the industrial high school graduates, as well as the graduates of the present type of cultural high schools.

14. Vocationalized college academic courses and a general tendency in all schools to arrive at culture through vocational courses, manual training, and the like, reversing the present system.

15. Provision for a commission or committee with a managing secretary to keep the industrial courses in line and up with practice, and each school within its legitimate field.

16. Improved methods of teaching.

In connection with item 16, the writer has submitted the Spherical Want-System as meeting nature's demands in training boys and girls. It is hoped that the reader has reached the conclusion that the system, while quite the opposite in many respects to that in use in the schools, is nevertheless not new from the standpoint of nature. There could be no hope for the proposed system if it were. As explained in the various sections of this paper, principally in sections II, III, IV, V, VII and VIII, the proposed system involves the following considerations:

The two great incentives are wants and pain. The latter is the greatest friend to all animals, giving prompt notice of the infringement of the laws of nature. Pain thus sets limits to those actions or non-actions which constitute infractions of the laws of health. It is also properly used by society and the state as a protection against the carelessness and selfishness of the individual or of groups of individuals which interfere with the normal functions of the state and society.

But as the most effective incentive to those actions which

result in school-learning, the writer believes that the wants (needs, necessities and desire of present and future reward) of the individual have no equal. Pain may be used as a brake to stop infractions of school rules, when necessary, but the wants should constitute the driving power. It is the teacher's problem to use wants that good habits may be formed by repeating proper and desirable actions and to use pain, if necessary, that bad habits may be prevented. The difference between an interested worker and a slave illustrates the point.

One does not develop either muscles or brain by watching another perform or by listening to his lectures. One really learns only by doing, or, rather, by thinking and doing things. The process of learning is the same in all cases; when one learns to swim or read, play football or cards, study to become an engineer or tie a cravat. For example, a boy sees a new kind of cravat and wishes to learn how to make the tie. He reads about the method, or studies the method illustrated in steps by pictures, or he obtains a demonstration (experimental lecture) by a friend or clerk. Guided by his teacher, or struggling alone, he finally succeeds in making a semblance of the knot. After a few weeks of daily practice he may think of something else while knotting his cravat. He has *learned* how.

In much of the present school work, pupils are frequently assisted in tying their scholastic cravats until, sometimes, they can struggle through the ordeal alone, when they are allowed to believe that they have become real cravatters in that particular study, when as a matter of fact, they may have only acquired the correct idea.

To follow out the cravat idea, a further study of colors and effects, styles and combinations for different times and places, the manufacture, distribution, sale, profit, cravat trusts, factory mechanisms, factory conditions, wages of employees, social welfare, etc., and we shall then have tied our cravat knowledge to all other parts of our sphere of knowledge and become at least cultured in so far as cravats are concerned—a Doctor of Cravats.

The following indicates the trend of the proposed system:

1. Placing the child or student in such a *sphere of observation,* or environment, as will induce desirable *wants* in the child.

2. Provision of a sphere of action containing those things necessary for the repeated *actions* in satisfying these wants and thus fixing the desired habits.

3. Assumption that the home, community and church must all be considered, as well as the school and playground, as a part of the spheres of observation and action.

4. Provision of automatic discipline, applied by pupils, parents and teachers, to set definite *limits* to action, using pain when necessary.

5. Building a *sphere of knowledge,* consisting of firmly fixed, desirable mental and physical *habits,* by means of the real (and imagined) personal experiences of the child.

6. Provision for the consistent and *regular expansion* of the sphere of knowledge from *birth* to adult life, by applying new ideas to the daily life.

7. Keeping in mind that faculties not used will disappear and those overworked will be lost.

Experimental Application.

A trial grade school would demonstrate the feasibility of the Spherical-Want System in a few years, but this test might also be made fairly well with certain manual and vocational courses for boys and girls, since they offer an excellent opportunity for demonstration in spite of the previous grade training of the pupils. A change in method and attitude on the part of the teachers and a comparatively small change in the subject matter and arrangement of the courses would permit a more or less satisfactory preliminary trial of the proposed system. Any college teacher who can overcome the inertia of his own mental habits and who will give this system a fair trial should obtain good results with relatively less work and cost than is generally obtained at present, and in spite of the previous training of the students.

PART II.

PROCEEDINGS OF THE SOCIETY.

The following paper was presented and discussed at the Minneapolis meeting. Brief written contributions, if sent to the Secretary promptly and if approved by the Publication Committee, will be printed in an Appendix to Vol. XXI of the PROCEEDINGS now in press.

THESIS DIRECTIONS FOR STUDENTS, WITH LIST OF MECHANICAL ENGINEERING TOPICS.

BY H. WADE HIBBARD,

Professor of Mechanical Engineering, The University of Missouri, Columbia.

The degree of Mechanical Engineer is given by the University of Missouri after three years in the School of Engineering following two years in a college of arts and sciences.

The contents of this paper are placed upon the bulletin board in the mechanical engineering design room of the second-engineering-year students about the middle of the year.

This paper is divided into two parts, Directions and List of Topics. For the second-year men, both parts are important. For this society, the list is especially offered, as being the result of a very large amount of work done two years ago, comprising some 1,500 titles. It is a list of topics or suggestions more or less detailed, intended to cover the entire range of mechanical engineering, out of which thesis subjects can be formulated.

DIRECTIONS.

For the Second-Year Students. A candidate for the degree should settle upon a thesis subject at the earliest possible date, the limit being one month after the fall registration in the third (last) year of the candidate. The subject must be acceptable to the teacher or teachers under whose special oversight it comes, and to the Chairman of the Department of Mechanical Engineering, who together form the committee for that thesis.

The thesis work of a student for the first semester requires only one-fifteenth of his time in a normal full registration of fifteen credit hours per week. During this time there will be

at least semi-monthly conferences between the student and the teacher in charge of his thesis. All preparatory thinking must be done and plans fully matured, so that the actual detail work will begin promptly at the opening of the second semester. Credit and grade for one hour is given at the end of the semester upon presentation of a satisfactory written report covering the following items:

1. Selection of subject.
2. Reading upon subject selected, with authors, titles, pages read, etc.
3. Correspondence, if any, upon subject.
4. A well-planned outline of work to be done.
5. Any preliminary work which has been done.

The real work on the thesis is in the second semester. The number of credit hours permitted for registration and the same or a less number of credit hours granted at the end of the semester, with of course the grade, rest with the committee on that thesis. The minimum registration is two hours out of a normal of fifteen; the maximum is decided for each case, and depends upon the student's other required courses, upon his personality and need, the scope of the subject and the facilities for investigation.

A thesis must have

1. Title Page,
2. Table of Contents,
3. List of Illustrations (if any),
4. Syllabus,
5. Subject matter or body of the thesis,
6. Conclusion (clearly drawn and expressed in curves if possible),
7. Bibliography (if books have been consulted),
8. Index, thoroughly cross referenced.

(Then follow details as to paper, typewriting, margins, two copies, inserts, and the like.)

A thesis may be

1. A Record of Experimental Research, or
2. A Design, or

3. A Compilation (collection of the facts, arrangement of these facts, deductions from these facts).

A thesis should be an original, independent piece of work; under oversight and guidance sufficient only to prevent waste of time and to make it of most value to the student and to the profession.

A thesis should be handled by the student as a real engineer would handle it.

Out of a thesis should be obtained

1. Educational value, as
   - (*a*) Self-reliance.
   - (*b*) Thoroughness in going to the bottom of the subject.
   - (*c*) Spirit of research.
2. Results of value to the profession, if possible. Hope, expect and so work, that your thesis may be accepted for publication and paid for by an engineering paper.

If the thesis is to be experimental on some mechanical appliance, the appliance should be of full commercial size and the experiment made on a commercial scale, and to represent actual engineering conditions.

Care should be taken to choose a subject not too extensive to be handled properly in the time or with the money available; the thesis may well be a very small subdivision of perhaps a large subject.

A thesis is likely to be especially satisfactory if the student has been previously especially interested in the subject or has had some experience in that line.

Before choosing a subject it is wise to

1. Look at subjects of recent theses in the engineering library. Examine their contents, extent, methods, analysis, subdivisions, arrangement, etc.

2. Ask some of your outside friends, especially engineering friends, during the Easter vacation and your next summer vacation, regarding what they would like to see investigated.

3. Write and ask the same of some of the engineering firms whose catalogues you have obtained in your Student Branch of A. S. M. E.

4. Examine latest index to current periodical engineering literature.

5. Examine table of contents of A. S. M. E. annual *Transactions.*

6. Examine table of contents and also the contents of Kent's Pocket-book and Hütte.

7. Examine the analysis of papers in the A. S. M. E. *Transactions,* as given here on page 133.

8. Note the subdivisions of the entire mechanical engineering profession, as divided into five groups by a committee of the A. S. M. E., given here on page 134.

9. Note the thirty-eight sub-committees of the A. S. M. E., given here on page 135.

10. Read over the very large number of thesis topics given herewith, most of which are merely suggestive, out of which detailed thesis subjects could be formulated, and some of which are already suitable for thesis subjects as given. They are grouped in accordance with the thirty-eight sub-committees of the A. S. M. E.

11. Look at list of thesis subjects from another school of engineering, given here on page 159.

12. Read the eighty-four actual thesis subjects formulated by the Department of Electrical Engineering, on page 162.

After you have followed the above twelve suggestions, consult with one or all of the teachers of the department.

A student should expect to spend a considerable amount of his own money on his thesis equipment. As much as $50 has been so spent by a student who did not have much money and was obliged to be very economical. It has been the policy of the Department of Mechanical Engineering to buy from a student, at from one-third to one-half its cost, any apparatus desirable to be kept by the Department for further laboratory use. Equipment and instruments owned by the department, as also steam, water, gas, gasoline, compressed air, and electricity, are furnished free.

The thesis, by order of the Faculty of the School of Engineering, must be handed in on or before May 15, to the Chairman of the Department of Mechanical Engineering.

List of Topics.

1. Analysis of Papers in A. S. M. E. *Transactions*, p. 133.
2. Groups in Mechanical Engineering Profession, p. 134.
3. The Thirty-eight Sub-Committees of A. S. M. E., p. 135.
4. Thesis Topics, p. 136.
5. Thesis Subjects from Another Engineering School, p. 159.
6. Electrical Engineering Thesis Subjects, p. 162.

1. Analysis of A. S. M. E. Papers.

1905 to 1910.

Abbreviations: A = Analytical; D = Descriptive.

"No." refers to number of papers delivered during this period.

	No.		No.
Air Compressors, D	1	Flow of Gases and Fluids, A, 2; D, 1	3
Automobiles and Materials, D	4	Fire Protection, D	1
Aeronautics, D	1	Gases, Miscellaneous, D, 1; A, 1	2
Boilers, also Accessories, D, 8; A, 4; D and A, 1	13	Gas Power, A, 2; D, 9; D and A, 1	12
Blowers, A	1	Gearing, A, 1; D, 2	3
Bearings, A, 2; D, 1	3	Hydraulics, D	1
Condensers, D	1	Heat & Heating, A, 1; D, 1	2
Cast Iron, A	1	Industrial Engineering, D, 5; A, 1	6
Concrete Construction, D, 1; A, 1	2	Impact, D	1
Cement Kilns, D	1	Locomotives, D, 5; A, 1	6
Calorimeters, D	1	Marine and Naval Eng., D	2
Clutches, A	1	Meters, Gases, etc., D	6
Coke Ovens, D	1	Metric System, Argumentative.	1
Cleaning Apparatus, D	1	Machine Tools and Mach. Tool Work, D, 3; A, 2; Argumentative	6
Cooling Towers, D and A	1	Metallurgical Mchy., D	1
Conservation, D	1	Ordnance Work, D	1
Conveying and Hoisting Machinery, D	7	Power Plants, D, 3; A, 2	5
Dynamometers, D	3	Pumps, D, 3; D and A, 1; A, 1	5
Education, D, 2; A, 1	3	Patterns, D	1
Elevators, D	2	Power Transmission and Transmission Machy, D	3
Engines, Steam, and Engine Parts, D, 5; A, 4	9		
Engines, Gas, D	2		
Fuels, A, 2; D, 3	5		
Foundry, D, 7; A, 1	8		

Pitot Tube, D, 1; D and A, 1.	2	Subway Ventilation, D	1
Photography, D	1	Salt Manufacture, D	1
Refrigeration, A, 1; D, 1	2	Specific Heat of Steam, A, 3; D, 2	5
Roof Construction, D	3	Turbines, Water, D	4
Railway Motor Car, D	1	Turbines, Steam, D, 2; D and A, 1	3
Standards, Report of Committee	1	Valves, A	1
Smoke Prevention, D	1	Vapors, etc., D	1
Superheaters, D, 7; A, 2	9		
Screws, D	2		

2. Groups in Mechanical Engineering Profession.

A committee of the American Society of Mechanical Engineers has divided the scope of mechanical engineering practice into the five groups below. Some of the separate items are given under each head. The list is by no means complete, not even nearly so, neither are the items listed necessarily the most important of those which could be placed in their group. Those that are given are intended to be suggestive of the great field which is covered by the science of mechanical engineering.

1. MACHINERY AND APPARATUS FOR MAKING MACHINERY.

Equipment for pattern making, forging, foundry and machine shops, including all hand and machine tools and equipment for sheet metal and plate work, die sinking, stamping, annealing and all other special branches.

2. MACHINERY AND APPARATUS FOR THE PRODUCTION OF MATERIALS AND ARTICLES OF COMMERCE AND MANUFACTURE.

Iron,	Rubber,	Cloth,
Steel,	Paper,	Shoes,
Copper,	Sugar,	Buttons,
Coke,	Alcohol,	Carpets,
Glass,	Flour,	Brick,
Paint,	Oils,	Tile,
Varnish,	Greases,	Nails,
Cement,	Thread,	Wire,
Chocolate,	Soap,	Agricultural
Starch,	Fire-arms,	Implements,
Rope and Twine,	Fire Protection,	Canned Food,
Scales, Balances,	Fire-protection Apparatus,	Stoves,
Furniture,	Ice,	Fertilizers,
Refrigerators,	Sewing Machines,	Pottery,
Dyes,	Automobiles,	Brooms,
Explosives,	R. R. Cars,	Salt.

3. MACHINERY AND APPARATUS FOR EXECUTING SPECIFIED PROCESSES.

Rolling,	Hoisting,	Drying,
Casting,	Conveying,	Bleaching,
Stamping,	Excavating,	Dyeing,
Tempering	Lighting,	Printing,
Plating,	Lubricating,	Engraving,
Crushing,	Signaling,	Painting,
Grinding,	Fuel Gasification,	Refrigeration,

Land and Water Transportation,	Pumping,
Adding Machines,	Compressing,
Calculating,	Pulverizing,
Typewriters,	Evaporating,
Freezing,	Canning,
Melting,	High Pressure Water System.

4. MACHINERY AND APPARATUS FOR GENERATING POWER.

Water, Steam, Gas and Oil Power Plants and all Auxiliaries, Fittings and Connections.

5. LABOR AND ECONOMY FACTORS IN MANUFACTURING AND TRANSPORTATION INDUSTRIES.

Accounting,	Fire Insurance and Protection,
Industrial Betterments,	Specifications,
Shop, Factory and Railroad Organization,	Education of Workmen and Managers,
Time Study,	Apprenticeship Courses,
Contracts,	Vocational Schools,
Wage Systems,	Technical Colleges,
Accident Protection,	Efficiency Systems.
Patents and Patent Laws,	

3. Thirty-eight Sub-Committees of the A. S. M. E.

COVERING ENTIRE RANGE OF SUBDIVISION OF MECHANICAL ENGINEERING PROFESSION.

1. Textiles	9. Metals and Metallurg. Mchy.
2. Paper and Wood Pulp	10. Foundry
3. Sugar	11. Machine Shops
4. Cement	12. Agricultural Machinery and Implements.
5. Glass	
6. Clay Products	13. Mining and Ore-Dressing Mchy.
7. Leather and Leather Products	14. Excavation and Dredging
8. Lumber and Wood Products	15. Hoisting and Conveying

16. Road Transportation
17. Marine Transportation
18. Rail Transportation
19. Steam Power and Plant Equipment
20. Gas Power and Plant Equipment
21. Water Power and Plant Equipment
22. Air Machinery
23. Pumping Machinery
24. Electrical Machinery
25. Heating and Ventilation
26. Refrigeration and Ice Making
27. Ordnance and Fire Arms
28. Industrial Buildings
29. Fire Protection
30. Protection of Industr. Workers
31. Administr. Industr. Estab'mts
32. Mainten. and Deprec. Plant and Equip.
33. Relations with Architects
34. Relations with Metallurgists
35. Relations with Civil Engineers
36. Relations with Mining Eng'rs
37. Relations with Chemical Eng'rs
38. Relations with Electr. Eng'rs

4. Thesis Topics.

CLASSIFIED ACCORDING TO THE 38 SUB-COMMITTEES OF THE A. S. M. E. OF PREVIOUS PAGE.

1. TEXTILES.
2. PAPER AND WOOD PULP.
3. SUGAR.
4. CEMENT.
    1. (See 19 for concrete boiler settings, concrete stacks, concrete expansion and contraction).
    2. Conveyors in cement plant (see also 15).
    3. Concrete-block machinery.
    4. Machinery for manufacture of Portland cement.
    5. Foundation bolts in engine concrete foundations.
    6. Dampness penetration of concretes, experimental.
    7. Abrasion of concrete.
    8. Electrolysis of reinforcement.
    9. Tests of Portland cements, slags, etc.
    10. Tests of stones and sands suitable for concrete.
    11. Tests of raw materials for Portland cement.
    12. Geological and commercial (as regards fuel, transportation, labor supply, demand) map of Missouri materials suitable for manufacturing Portland cement. Involves considerable knowledge of chemistry.
5. GLASS.
    1. (See 29 for wire-glass in fires).
    2. Tests of the various prism glasses for deflecting light into rooms.
    3. Heat transmission of different thickness of same glass.
    4. Heat transmission of different thickness of different glasses.
    5. Heat transmission of different thickness of different glasses, with air space between.

6. Investigate possibility of making air compressor or in general a gas compressor of this material possibly reinforced.
7. Investigate possibility and limitations of its use for bearings, coefficient of friction.
8. Relative strength of wire-glass *vs.* plain plate glass.

6. Clay Products.

1. Resistance to flow *vs.* diameter, of tile flues and brick flues.
2. Expansion and contraction of fire-brick.
3. Fire-brick; refractory *vs.* tough. Cooperation with chemical engineers.
4. Fire tile for boiler tubes.
5. "Compilation Thesis" of clay-product manufactures of Missouri.
6. Iron-reinforced fire-brick.
7. Brick-making at Miller's plant, Columbia; analysis of mechanical engineering and scientific manufacturing.

7. Leather and Leather Products.

(Leather Belts, see 11).
(Belt conveyors for coal, etc., see 15).
Shoe-making machinery.

8. Lumber and Wood Products.

1. Engineering uses of wood; freight cars, pattern shops, aeroplane frames, aerial propellers. (Propeller design, see 20: 73).
2. Development of "The Art of Cutting Wood."
3. Tests of tools and cutting edges, speeds, etc., for wood-working machinery.
4. Paint for wood preservation. Coöperate with chemist.
5. Tests of wood.
6. Specifications for the purchase of wood.
7. Characteristics of wood.
8. Furniture-making machinery.
9. Wood-working machinery.
10. Timber-preserving plants.
11. Causes of wood deterioration. (Care of patterns, see 10).
12. Heat transmission of woods; dry and wet.
13. Machinery for lumbering.

9. Metals and Metallurgical Machinery.

1. (See 11 for tool steels, "Art of Cutting Metals," springs).
2. (See 10 on foundry).
3. (See 19 for metal deterioration by superheated steam).
4. Specifications for purchase of metals.
5. Tests of metals in civil engineering materials laboratory.
6. Repeated loads. Compound loads. Elastic breakdown.
7. Effects of percentages of vanadium, tungsten, nickel, etc. in steels.

8. Protective coatings for metals (paint, magnetic oxide, concrete).
9. Tests of above.
10. (On paint for wood, see 8).
11. Geological map of materials suitable for good paint.
12. Hardness tests of metals by scleroscope.
13. Friction tests of materials.
14. Forging presses; design.
15. Blast-furnace machinery.
16. Rolling mills.
17. Open-hearth furnace machinery.
18. Electric welding, tests of welds.
19. Oxy-acetylene welding and cutting.
20. Gas producers for metal heating. (See 20 for gas producers in general).
21. Hydrostatic tests of cast steel cylinders.
22. Hydrodynamic shock tests of cast iron cylinders.
23. Hydrodynamic shock tests of cast steel cylinders bushed with cast iron.
24. Deterioration of wrought iron in repeated working.
25. Growth of cast iron in repeated heatings.
26. Case hardening by carbon monoxide.
27. Heat treatment of spring steel. (See 11 on springs).
28. Corrosion tests of metals. (See 21, 25 and 26 for pipe corrosion).
29. Drop forging.
30. Plate pressing; hot, cold.
31. Production machinery in blacksmith shops.
32. Electric steel manufacture.
33. Etching; microscope; microphotograph; in the study of metals, heat treatments, etc.
34. Microstructure in fatigue of metals.
35. Heat treatment of alloy steels.

10. FOUNDRY.

1. (See 15 for bucket materials, in hoisting and conveying machinery).
2. (See 8 on wood for patterns).
3. (See 9 on metals).
4. Core making; core mixtures, temperature of baking.
5. Baked sectional molds in machined, metal flasks.
6. Use of cores in the place of patterns in steel foundry. (See Commonwealth Steel Co. of E. St. Louis, and Federal Steel Co.).
7. Location of deposits of molding sand in Missouri.
8. Molding sands; composition for different purposes, special sand for facing molds for steel castings.

9. Pattern design for steel castings.
10. Shrinkage of steel castings.
11. Strength of steel castings.
12. Cause and prevention of blow-holes in steel castings.
13. The field for very high strength cast "gun iron."
14. Recent developments in malleable cast iron.
15. Classification of patterns.
16. Care of patterns.
17. Use of chills to prevent shrinkage cracks in difficult castings.
18. The continuous foundry. (Compilation thesis).
19. Air hoists for foundry. (See also 15 for hoists and conveyors).
20. Machine molding.
21. Pneumatic rammer.
22. Jarring machines for very large work.
23. An exclusive molding-machine foundry.
24. The lifting pressure of molten metal on cores.
25. Experimental study in Univ. of Missouri foundry on the shrinkage problem in iron castings of various shapes.
26. Various mixtures of pig and scrap.
27. Fuel used per ton of iron.
28. Temperature of different zones.
29. Air requirements; power to drive blower.
30. Fluidity of various mixtures.
31. Utilization of waste heat in foundries.

11. Machine Shops.
    1. (See 31 on shop costs of production and other administrative problems). (See 28 on location of machines).
    2. Analysis of the manufacture of parts of a small straightening press.
    3. Location of motors on machine tools. (See 24 on electrical machinery).
    4. Limitations in individual motor drives for small machines.
    5. Springs; (see 9 for heat treatment of spring steel); analysis of stresses, design, tests, materials.
    6. Friction as an aid to springs; spring dampening; shock absorbers; the work of recoil.
    7. Limit of pressure for ball bearings.
    8. Tests of roller bearings.
    9. Experimental study of thrust bearing.
    10. Shaft hanger design.
    11. Analysis and field for shafting as transmission machinery.
    12. Clutches; holding power, ease of release, durability.
    13. Belt shifters, durability.
    14. Belting upkeep.

15. Belt deterioration.
16. Leather belts.
17. Belt fastenings. (See 32 on Maintenance and Depreciation).
18. Horsepower of belting.
19. Rope drives for industrial plant.
20. Tests of ropes for rope drives.
21. Sheaves for rope drives, diameter, slot, material.
22. Chain-belts for machines:—friction, strength, deterioration (strength, slackness, efficiency).
23. Uses of power transmission dynamometer, tests with same.
24. Efficiency tests of some of form of universal joints carrying different loads.
25. Efficiences of various cut gears, analytically and experimentally determined.
26. Efficiencies of worm gears of different angles.
27. Lubricants: (Flash, chill, density, viscosity, friction, carbonization tests—all as related to costs).
28. Viscosimetry of remixed grease.
29. Viscosimetry of grease under great pressure.
30. Tests of hard grease as lubricant.
31. Amount and type of lubricant for various metals.
32. Pressure and lubrication.
33. Anti-friction metals. (See 19 for engine lubrication).
34. Grinding machinery; methods, preparation of work, field, costs, experiments.
35. Magnetic clutch for grinding machinery.
36. Magnetic clutch for metal cutting machinery.
37. Tests of tool steels.
38. Tool holders.
39. Several tests out of Taylor's "Art of Cutting Metals."
40. Drills; drill jigs.
41. The cold chisel as standardized for the pneumatic hammer. (See 22 for air machinery).
42. The scientific selection of files.
43. Experimental study of a file for cast iron (adapting a power hack-saw machine).
44. Analysis of a vertical-spindle, high-powered milling machine.
45. Die and stamp presses for cutting or shaping thin cold metals.
46. Fly-wheel presses.
47. Mechanical engineering analysis of several makes of typewriters, as regards manufacturing and operation.
48. Household sewing-machine efficiency tests.
49 Kinematics of sewing-machines.
50. Wedges.

12. AGRICULTURAL MACHINERY AND IMPLEMENTS.
    1. Cooperation with an agricultural student in a thesis.
    2. Tests of farm gasoline engine.
    3. Farm gasoline engine troubles.
    4. Farm tractors.
    5. Stresses in mowing machine parts. Ditto other machines.
    6. Windmills.
    7. Tests of lawnmowers. (See 20 for power lawnmowers).

13. MINING AND ORE-DRESSING MACHINERY.
    1. Coal-mining machinery, Missouri *vs.* Illinois mines.
    2. Mining progress in Missouri.
    3. Hoisting engines. Cables.
    4. Mine cars.
    5. Underground haulage plants; steam, cable, electric.
    6. Drills.
    7. Mining machines.
    8. Ventilating fans.
    9. Drainage.
    10. Tipples and towers.
    11. Screens.
    12. Make complete design, specifications and estimates for mine near Columbia.

14. EXCAVATING AND DREDGING.
    1. Sewer trenches.
    2. Dredger.
    3. Use of hydraulic nozzle in excavating, as over quarry in St. Louis Cement Co.
    4. Centrifugal pump in dredging.
    5. Pump *vs.* shovel.
    6. Design of an electrically-driven shovel (in place of a steam shovel).

15. HOISTING AND CONVEYING.
    (See 10 for air hoists in foundry).
    (See 13 for mine hoists).
    (See 19 for coal crushers and pulverizers).
    (See 4 for conveyors in cement plant).
    1. A. S. M. E., Vol. 30, p. 123–275.
    2. Belt conveyors for coal, ashes, ore, etc.
    3. Tests of belt material for above.
    4. Waterproof tests of belt material.
    5. Abrasion; resisting qualities of belt material.
    6. Belt-pulley diameter as related to life of belt.
    7. Angles of repose of various materials under various conditions.
    8. Belt-roller supports.

9. Fillers and dumpers.
10. Fundamental principles of endless conveyors, and discussion of all such conveyors by those principles.
11. Relative importance of requirements for conveyors in locomotive coaling station.
12. Bucket conveyors, friction, bucket material, lubrication, reciprocating feeders.
13. Scraper conveyors.
14. Reciprocating trough conveyors.
15. Screw conveyors.
16. Finger or hook conveyors.
17. Endless apron.
18. Aerial cable ways.
19. Pneumatic and water conveyors.
20. Chutes; angles of flow; roller chutes.
21. Freight-house conveyors.
22. Department-store cash and bundle conveyors.
23. Railroad and steamship power ramps.
24. Brewery conveyors.
25. Ice conveyors.
26. Cranes; traveling, trolley.
27. Sheave diameter as related to life of wire rope; or to physical qualities or chemical composition of the steel.
28. Wire rope tests (Kent).
29. Chain tests.
30. Hook design; tests.
31. Locomotive cranes; railroad wreckers.
32. The steam power plant of a locomotive crane.
33. Clam-shell buckets for run-of-mine in cars.
34. Industrial railway; cable, steam, electric, compressed air power.
35. Mechanical equipment of ore and coal docks of Great Lakes ports, for loading and unloading.
36. Coal-car dumping machines.
37. Crane installations and methods with English tarpaulin-covered flat cars.

16. ROAD TRANSPORTATION.
(See 20 for automobiles).
1. Stone crushers. (See also 4).
2. Road rollers.
3. Road scrapers.
4. Wheels.
5. Tires.

17. MARINE TRANSPORTATION.
1. Marine water-tube boilers, as especially adapted for use on the Great Lakes.

2. Producer gas for marine work.
3. Marine steam turbine, compilation of results.
4. Small gasoline power plant for launch.
5. Power equipment for submarines.
6. Hydroplane. (See 20 for aeroplane propellers).

18. Rail Transportation.

(See 13 for mine cars and haulage).
(See 15 for industrial railway).
(See 20 for Diesel locomotive).

1. Design of a locomotive boiler.
2. The support of the crown sheet of the locomotive fire box.
3. Stresses in boiler produced by temperature changes.
4. Experiments on heat transfer with a boiler tube, varying the length, diameter, gas velocity and temperature, water velocity, etc.
5. A study of the locations of broken stay bolts, with causes and remedy.
6. Life of stay bolts; tests by alternate bending, while hot and stretched, of different lengths, designs and materials.
7. The locations of cracks in locomotive boilers, causes and remedies. (Moberly shops.)
8. A study of locomotive boiler explosions.
9. The ignorant or vicious methods of workmanship in boiler shops.
10. The periodic inspection of locomotive boilers.
11. Comparison of mechanical stokers for locomotives.
12. Experiments on exhaust nozzles and smoke stacks, with steam, without gas; first connecting up with tests for American Railway Master Mechanics Association.
13. Mechanical draft for locomotives (Forney).
14. Smoke diminution.
15. Experiments on the causes of variation in efficiency of steam jet as a gas ejector (glass ejector tube and visible smoke).
16. A comparison of superheater designs for locomotives. (See also 19 for superheat.)
17. The superheating effect of steam pipes in smoke box.
18. Theoretical determination of correct amount of superheat for a given locomotive.
19. Thermodynamic analysis of Mallet articulated compound locomotive using superheated steam.
20. The B. t. u. loss in air-pump exhaust.
21. The increase in efficiency by using a feed pump and heating feed water by exhaust steam from feed pump or air pump.
22. Comparison of theoretical valve motion diagrams and their adaptability for use in designing or analyzing locomotive valve gears.

23. Study of various locomotive valve gears.
24. The balancing of slide valves.
25. Power reverse gears.
26. B. t. u. wall loss from live steam to exhaust-steam passages in saddle casting.
27. Hydrostatic tests of full-sized pistons of different designs, cast iron and cast steel.
28. Piston packings for cylinder or piston valve.
29. Sight-feed lubricator with saturated and superheated steam.
30. Pump feed lubricator.
31. Piston-rod packings.
32. Cross-head designs.
33. Stresses in locomotive connecting and parallel rods.
34. Mathematical or experimental analysis of loads on one of the details of a connecting rod.
35. Journal boxes for driving axles; design; materials (cast steel, cast iron, gun iron, phosphor bronze, combinations); lubrication, bearing pressures.
36. American and European car axle boxes.
37. Stresses in car axles.
38. Locomotive trailer truck designs.
39. Design of front power truck of Mallet articulated compound locomotive.
40. Compression, inertia and counterbalancing in locomotives.
41. Balanced locomotive.
42. Vertical and horizontal rail stresses induced by steam and electric locomotives.
43. Tests of rail joints.
44. Analysis of mechanical efficiencies of locomotives of different designs and under different conditions.
45. Curves of "characteristics" of a locomotive.
46. Rational design of cast steel locomotive frame.
47. Rational design of one-piece cast steel tender frame.
48. Structural steel tender frame.
49. Mechanics of engineering analysis of a steel coal car; steel passenger car.
50. Mechanics of engineering analysis of a six wheeled passenger car truck.
51. Hopper-bottom mechanism for coal and ore cars.
52. Theoretical and practical analysis and comparison of several varieties of car couplers. (On draft gear see 11 for springs, shock absorbers.)
53. Analysis of the elements in stopping a train.
54. Foundation brake design.
55. Truck brake design.

56. Development of engineman's brake valve, triple valve, slack adjuster, brake beam, hose coupler, automatic air couplers.
57. Analysis or tests of preceding.
58. Tests of hose.
59. Tests of air pumps. (See 22 for other compressed air).
60. Train lighting and ventilation.
61. Toilet equipment in cars.
62. A locomotive test, if accompanied by draw-bar pull and track profile, etc.; suitable instruments and connections; safety.
63. Study of train resistance.
64. Locomotive terminals. (See 15 for power handling of coal and ashes).
65. Smoke diminution at locomotive terminals.
66. Coaling station equipment.
67. A complete coal-premium system for locomotives.
68. Lay-out of locomotive or car repair shop.
69. Design, construction, operation and repair of locomotives and cars; (taking a detail).
70. Specialized machinery for construction or repair of locomotives and cars.
71. Depreciation of railway equipment. (See 15 on power handling for freight terminals).
72. Signal and interlocking machinery.
73. Compilation of correspondence with the industrial agents of railroads interested in upbuilding manufactures in Missouri.

19. STEAM POWER AND PLANT EQUIPMENT.

(See 6 on fire brick and tile).
(See 25 for heat distribution from central heating plant in a city).
(See 17 for marine water tube boilers, especially on Great Lakes).
(See 15 for coal and ash-handling machinery, belt conveyors, etc).
(See 11, machine shop, on belting, rope drives). (See 13 for mine hoisting engines).
(See 25 for concentration, evaporation and drying in the industries).
(For Central Station Economics see also 24).
(See 18 for additional topics).

1. Coal tests of Missouri coals.
2. Inexpensive and quick (but fairly accurate) methods for learning the real commercial value of coals for the small user who wishes to select his coal.
3. Coal specifications.
4. Coal deterioration.

5. Coal *vs.* coke (gas house or coke-oven coke) for house use.
6. Tests of heaters for heating water in residence; (1) coal, (2) gas.
7. Tests of laundry stoves without water back, for heating wash boilers and flat irons.
8. London down-draft kitchen range for smoky coal.
9. Flue gas analysis.
10. Influence of hydrogen, CO and moisture on chimney losses.
11. CO_2 recorders.
12. Comparison of pyrometers.
13. Comparison of coal calorimeters.
14. A study of boiler explosions.
15. The inspection and insurance of stationary boilers; lessons of the statistics.
16. Application of the two general principles in boiler design: (*a*) changes in steam pressure must not alter the shapes of the boiler; (*b*) changes of temperature in the metal will surely cause alteration in shape, and must be provided for safely or the temperature changes avoided.
17. The selection of steam boilers.
18. Problems of radiation.
19. Interrelations of conduction, convection and radiation in boilers.
20. General conditions for boiler economy.
21. Compilation thesis of tests made by *disinterested* people, not by manufacturers, sellers or agents, to show what may reasonably be expected of boilers, engines, turbines, etc.
22. Effect of rate of driving upon over-all boiler efficiency.
23. Economy of heating air supply; experiments in laboratory.
24. Increase of coefficient of heat transfer from hot gases to water in boilers from 3 to 1000. (See *Power*, November 21, 1911, p. 767. See Lucke in *Transactions* of Am. Ry. Master Mechanics Assoc., 1909). (See 25 for heat transmission in heating and ventilation).
25. Thin scale blisters.
26. Gas and water-scrubbing principle in boilers; compilation, tests.
27. Counter current.
28. Steam flow meter.
29. Relations between intermittent feed, boiler pressure, draft and furnace conditions, and reading of steam flow meter. (See Hunter curves, St. Louis).
30. Boiler settings of reinforced concrete; plate-covered settings.
31. Expansion and contraction of reenforced concrete.
32. Fire-resisting tests of concrete made of cement and crushed fire-brick.

33. Special boiler furnace settings; length of fire-brick arch.
34. Tests of boiler steel worked at objectionable blue temperature; ductility, strength, cracking.
35. Tests of boiler steel at blue temperature (same for cast iron).
36. Durability test of clay tile for boiler tubes.
37. The most economic riveted boiler seams, considering every factor and including interest, etc.
38. Boiler proportions for blast furnace gas.
39. Smoke recorders.
40. Study of smoke, by Ringelmann charts, and by smoke gage, of our Columbia factory and business and residence chimneys, with causes and improvements.
41. Relation of character of coal to prevention of smoke.
42. Comparison of mechanical stokers.
43. The favorable features of mechanical stoking.
44. Necessary features for the securing of successful operation of mechanical stoking; speed, coal gate and damper opening.
45. Deterioration of metals, especially of cast iron in superheaters.
46. Specific heats of superheated steam and gases.
47. Coal crushers; jaw, rotary, flail.
48. Coal pulverizers. (See 15 for coal and ash-handling machinery, belt conveyors, etc.).
49. Reinforced concrete stacks; lining.
50. Effect of smoke gases on concrete setting of chimneys.
51. Corrosion of concrete and of reinforcement, by sulphur.
52. Mechanical draft.
53. Comparison of prime movers; steam (reciprocating engine, turbine), gas, water.
54. Engine tests using wet steam, dry saturated steam, and superheated steam; entropy diagram analysis.
55. Turbine tests of same kind.
56. Power plant of office building.
57. Friction of steam on rotating discs.
58. Heat storage; heat flywheel; Rateau regenerator; experiments on small scale in laboratory.
59. Experiments with steam-turbine nozzles.
60. Tests of steam turbine running against various pressures of exhaust steam heating.
61. Experiments on dry-tube condensing for surface condensers.
62. Influence of tube shape in surface condensers.
63. Tests on the problems of the cooling tower, spray and pond.
64. Design of most efficient fan for cooling tower. (See also 25).
65. Moisture in exhaust steam; tests to determine moisture in steam and the gain in capacity of condenser if the moisture were removed by means of a separator.

66. Heat transfer to water at temperature below 212°, (possible large variety of conditions).
67. Heat transfer in economizers.
68. Incrustation, corrosion, priming and remedies.
69. Water softening, machinery for, effect of scale.
70. Steam-pump tests; conditions of engine tests above.
71. Injector tests under various steam and water conditions.
72. Tests of sight-feed lubricator, cast iron with superheated steam, and lubrication.
73. Feed-water regulators.
74. Precise water-level control by use of steam separator or steam loop or otherwise.
75. Cracking off thin scale in vertical water-tube boiler by contraction and expansion of corrugated tubes by intermittent feed regulation.
76. Steam separators.
77. Steam-pipe design; piping systems.
78. The flow of high-pressure steam in pipes of various sizes, also through bends and valves.
79. Bending pipes at brittle blue heat.
80. Investigation of quality of steam to Sturtevant engine as affected by taking steam from bottom or top of steam main.
81. Experiments with graphite and with oil-graphite lubrication of steam cylinders and valves. (See 11 and 18 on lubricants).
82. Oil separators.
83. Cost of power; losses of power in factories.
84. Power-plant load-factor betterment by (1) heating the building or shop; (2) heat distribution by sale; (3) combining electricity production with ice making or with pumping.
85. Indicator reducing motions in University of Missouri laboratory.
86. Tension of indicator-drum springs.
87. Stretch and durability tests of indicator cords.
88. Suitable sizes for indicator diagrams; steam, air and gas, height and length.
89. Producing an entropy-temperature diagram direct by instrument.
90. Comparison of steam calorimeters.

20. Gas Power and Plant Equipment.
1. Gas works economies.
2. Gas meters; mechanical, thermo-electric.
3. High-pressure gas transmission (as to farmers many miles away from Camden, N. J.).
4. Gas velocity and Pitot tube.
5. Gas analysis.
6. Gas calorimetry.

7. Cleaning of gas.
8. Isolated gas, gasoline or acetylene plant for lighting a farm house and barns.
9. Compression and storage of Pintsch gas.
10. Transportation of stored acetylene gas.
11. By-product gases and fluids.
12. Cleaning of blast furnace gas for use in steam boilers and in gas engines.
13. (See 9 for gas producers in metal heating).
14. Design thesis or compilation thesis on bituminous gas producers.
15. Experiments in the physical theory of coal carbonization.
16. Clinkering and caking in gas producers.
17. Causes in bituminous producer for variations between theoretical estimates and subsequent analysis.
18. Decomposition of tar.
19. Internal combustion fuels.
20. Gasoline fortified with ether, picric acid or other high explosive.
21. Alcohol in internal combustion engines.
22. Explosion of carbon dust; early lycopodium engine.
23. Carbon dust as an engine fuel.
24. Explosion of gases in a closed vessel.
25. The effect of different pre-explosion pressures upon explosive mixtures.
26. Stratification of charge in two-cycle engines.
27. Fluctuations of explosion pressures under constant load conditions.
28. Explosion waves.
29. Burned gases in dilute mixtures, and combustion rapidity.
30. Suppression of heat at combustion.
31. Specific heat of gases at high temperatures.
32. Carbon deposits and rich charges, for various fuels.
33. Cooling of air and gas supply as a power gain for overloads.
34. Heating of air and gas supply as an efficiency gain for underloads.
35. Tests of carbureters for gasoline, alcohol, fortified liquids, etc.
36. Experiments on size and length of small passages as a backfire check.
37. Automobile ignition.
38. Experiments with jump spark.
39. Normal *vs.* heavy spark.
40. The automobile magneto.
41. Cam design for very high-speed engines.
42. Waste heat of gas engines.
43. Economical use of compressed air for starting gas engines.
44. Diagnosis and remedies for starting and running troubles, the engines being divided into classes.

45. Experimental production of above troubles.
46. Automobile engine lubrication.
47. Experiments on carbonization of cylinder oils.
48. The lightening of reciprocating parts of automobile engines.
49. Special steels in automobile construction. (See 9 on alloy steels and heat treatments).
50. Radiator efficiency.
51. Air-cooled motors.
52. Experiments on shapes of ribbing for air cooling.
53. Comparison of brake efficiencies with the different cycles.
54. Practical conditions limiting ideal efficiency.
55. Analysis of difficulties delaying the gas turbine.
56. The compound gas engine.
57. Diesel engine, and locomotive.
58. Recent developments in large gas engines.
59. Small gas engines.
60. Experiments with a small gas engine.
61. Experiments on a two-cylinder gas engine using oil and the Diesel cycle.
62. On automobiles, except for engine, see 16.
63. The dust problem in vehicle machinery.
64. Tests of motor-cycle engine.
65. (See 12 for farm tractors and farm gasoline engines).
66. Power lawnmowers. (See 12 for lawnmowers).
67. Aeroplane materials; wood, metal, cloth.
68. Factors of safety in the parts of an aeroplane.
69. Wind pressure on aeroplane surfaces, struts, engine fronts, aviator, etc.
70. Automatic stabilization by center of pressure, by mechanical device.
71. Tests of efficiency of aeroplane propellers.
72. Use of anemometers and smoke.
73. Propeller design.
74. Propeller rupture.
75. The motion of free and constrained solids through air.
76. Balance sheet of energy used and wasted.
77. Air *vs.* water radiation.
78. Tests of aeroplane engine.
79. Centrifugal analysis of Gnome engine.
80. Gyroscopic analysis of Gnome engine.
81. Proportions of exhaust manifold.
82. The law of trespass in aeronautics.
83. Transportation common-law evolution and its return influence upon the engineering of transportation.
84. (See 17 for hydroplane).

21. Water Power and Plant Equipment.
    1. Turbine tests.
    2. Impulse wheels.
    3. Analysis of very small hydro-electric plants.
    4. Hydraulic machinery (presses, riveters, etc.).
    5. The design of joints for high-pressure street mains.
    6. Tests of flange couplings under repeated stresses.
    7. Reducing valves.
    8. Experiments on the stresses induced in pipe lines by the sudden closing of valves.
    9. Shock.
    10. The bursting of pipe fittings.
    11. Corrosion of high-pressure wrought iron street mains. (See 25 for pipe corrosion).
    12. Flow of water in one-inch pipes; curves, angles, straight.
    13. Flow of hot water in one-inch pipes; curves, angles, straight.
    14. Effect of changes in diameter upon flow of cold and hot water. (See also 25).
    15. Discharge from pipes through branches and side orifices.
    16. Comparison of water meters.
    17. Large water meter; mechanical type, venturi type, elbow type.
    18. Pitot tubes and pipe angle, as a water meter.
    19. Pitot-tube experiments.
    20. Weir experiments.
    21. Orifice experiments.
    22. Nozzle experiments.
    23. Fire nozzles.
    24. (For automatic fire sprinkler, see 29).
    25. The motion of a solid through a liquid.
    26. Impinging jets.
    27. Friction in hose.
    28. Lawn sprinklers.

22. Air Machinery.
    1. Vacuum house-cleaning; tests of machines, nozzles, hose, dust catchers.
    2. Tests of air-using tools (portable and semi-portable).
    3. Re-heating of compressed air just before using in air machinery.
    4. Tests of different methods of reheating.
    5. Piston compressors *vs.* turbo-compressors.
    6. Design of a piston compressor.
    7. Design of a turbo-compressor.
    8. High-pressure centrifugal compressors.
    9. Pre-coolers, inter-coolers, after-coolers.
    10. Cold *vs.* engine-room supply of air to our laboratory air compressors; same for the Diesel engine.

11. Transmission of compressed air.
12. Experiments on the performance of a windmill.
13. Experiments with sand blast.
14. Placing paint and cement by the air nozzle.
15. (See 11 for pneumatic cold chisel).
16. (See 18 for air brake).

23. PUMPING MACHINERY.
1. (See 13 for mine drainage).
2. Deep-well pumping.
3. Tests of different types of deep-well pumps: piston, turbine air-lift pumps.
4. Air lift.
5. Different arrangements of air-lift pumps.
6. High-pressure centrifugal pumps.
7. Steam drive *vs.* electrically-driven piston or turbine, pumps.
8. Tests of oil-engine or steam-engine-driven centrifugal pump for irrigation, where water is close to surface (e. g., Garden City, Kansas).
9. Tests on pumping engines with reference to cylinder condensation.
10. Tests of laboratory steam pumps.
11. High efficiency.
12. Water-works economies.
13. Analysis of the non-break-down sump pump of the Penna. R. R. Terminal, New York, as designed by Westinghouse, Church, Kerr & Co.

24. ELECTRICAL MACHINERY.
1. Steam and gas central-station economies.
2. Effect of power factor in economy of plant.
3. Use of floating synchronous motors to improve power factor.
4. Electrical machinery analysis as relating to mechanical engineering uses.
5. Use of induction motors.
6. Analysis of the mechanical engineering features of electrical machinery.
7. The most common troubles in electrical machinery; their diagnosis and cure.
8. (See 11 for location of motors on machine tools).
9. Design of an electrical-driven shovel, in place of steam shovel. (see 14).

25. HEATING AND VENTILATION.
1. (See 13 for mine ventilation).
2. (See 18 for train heating, ventilation).
3. Warming of air; divide into details.

4. Temperature and humidity control in heating.
5. Humidifying plant.
6. Cleaning of air.
7. Tests on air filters.
8. Efficiency tests of house furnaces.
9. Gas leakage in hot-air house furnaces.
10. The under-stoker house furnace.
11. High-temperature water heating.
12. Rapid-circulation hot-water heating; analysis, tests.
13. Accelerated radiation.
14. Heating by steam pipes buried in concrete flooring. (Morse Chain Co., Ithaca, N. Y.).
15. Transmission of heat through house walls, etc.
16. Moving of hot, warmed and unwarmed air by a fan.
17. Air-pipe diameter, bends, cross-section shape.
18. Tests of shapes of fan blades, speeds, etc.
19. Fan tests; capacity, pressure, power required. (See also 19).
20. (For cooling tower fan see 19).
21. (See 20: 73 for aeroplane propellers).
22. Electric fans.
23. Tests of anemometers.
24. Flow of cold water, hot water and steam in one-inch pipes. (See also 21).
25. Flow of the above in curves, angles and straights.
26. Effect of diameter changes on each of above two.
27. The influence of pitch on the flow of water (and steam and air) in pipes.
28. Heat distribution from central heating plant in a city.
29. Use of high-pressure, high-velocity distributing mains for steam heat, as against the opposite.
30. Pipe corrosion. (See 9 for corrosion of metals, 21 of water pipes).
31. Tests during service in church of Columbia.
32. The ventilation of the agricultural college auditorium.
33. Tests of baking ovens heated by city gas.
34. Tests of laundry drying-plant.
35. Centrifugal drying.
36. Concentration and evaporation in the industries.
37. Tests of heat loss by buried steam and hot-water pipes; naked, wood stave, conduit, tunnel.
38. Deterioration of combustible laggings.

26. Refrigeration and Ice Making.

1. Tests of refrigeration insulation.
2. Effect of percentages of asbestos to magnesia on conductivity.

3. Standard block-of-magnesia lagging.
4. Heat transmission of various pipes under various conditions of use.
5. Street distributing mains.
6. Corrosion of "Genuine Wrought Iron" *vs.* "Wrought Iron" (steel) pipes.
7. Effect of ice deposit on surface efficiency of refrigeration piping for low-temperature rooms.
8. "Scrubbing" inside and outside of refrigeration surface.
9. Design and test of heat radiator for test of amount of refrigeration entering a room.
10. Temperature control of cold-storage rooms.
11. Humidity control of cold-storage rooms.
12. Refrigeration—electric plant.
13. Losses due to opening boxes different periods and at different temperatures.
14. Protection of tanks against unclean foot-wear, in manufacture of ice for domestic use.
15. (See 15 for ice conveyors).
16. Refrigeration in hotels.
17. Guest-room cooling in hotels.
18. Refrigerator cars (ice *vs.* machinery).
19. Retail meat-shop ice refrigerator.
20. Tests of house refrigerators.
21. Ice-cream freezers; hand and power, efficiency in use of ice, salt, power.
22. Cooling rooms in residence in summer by ice (as suggested by Edison).

27. Ordnance in Fire Arms.
1. Manufacture of explosives.
2. Development of armor plate.
3. Gun thermodynamics.
4. Power cycle of disappearing-gun recoil and rise.
5. The disappearing gun under analysis of mechanics of engineering.
6. (See 11 on friction and shock absorbers).
7. Kinematics and strength analysis of the automatic pistol, rifle, and shot gun.
8. Radiation ribs of automatic military rifle. (See also 20).

28. Industrial Buildings.
1. Design of the layout of buildings for the manufacture of a given product.
2. On industrial railway, see 15.
3. Building design for University of Missouri power plant.
4. Cost of buildings.

5. Cost of earth excavation.
6. Concrete and steel buildings *vs.* wooden buildings as regards the shafting problem.
7. (On slow-burning construction, see 29).
8. Layout of machinery on a floor of a given factory.
9. Progress of work through a building, without doubling back.
10. (On administration of industrial establishments see 31).
11. Analysis of Columbia shoe factory.
12. Latrine design and oversight.
13. Proportioning of artificial lighting.
14. Saw tooth.
15. Round-house doors.
16. Round-house roof design.
17. Round-house floors.
18. Shop floors.

29. FIRE PROTECTION.

1. Causes of fires.
2. Chimneys.
3. Electric wiring.
4. Tests of defective wiring as producing fires.
5. Storage of inflammable material.
6. Steam-heat pipes.
7. Spontaneous combustion.
8. Friction.
9. Factory risks.
10. Prevention of fires.
11. Inspection; Missouri Fire Prevention Association.
12. Fire losses in Columbia; causes, suggestions for reduction.
13. Inspection and report upon fire risks in university buildings.
14. Inspection of old and new buildings of several classes in Columbia.
15. Reduction or increase of rates following inspection.
16. Slow-burning wooden construction of shops.
17. The automatic sprinkler.
18. Wire glass fire retardant.
19. Fire door design.
20. Automatic fire-door closing.
21. Fire extinguishers.
22. Fire-hose supports.
23. (See 21 for nozzles on fire hose, friction in hose).
24. Reducing liability for injury and death in fires.
25. Monograph on fire insurance.
26. Insurance engineering.
27. (Boston Manufacturers' Mutual Fire Insurance Co.).

28. (E. Atkinson "Fire Causes").
29. Fire insurance experiment station.

30. Protection of Industrial Workers.
    1. Protection of machines to prevent accidents.
    2. Protection of our engine laboratory to prevent accidents, yet not to hinder its use.
    3. Protection of our laboratory Bruce-Macbeth gas engine, to prevent all accidents in use by students.
    4. Analysis of foundry accidents.
    5. Electrical accidents in work shops.
    6. Railway accidents; individual or statistical.
    7. Sanitary plumbing.
    8. Effect of lights on eye.
    9. Lighting efficiently.
    10. Law of accidents and injuries.
    11. Employers' liability legislation.

31. Administration of Industrial Establishments.
    1. Graphical methods of plotting and analysis of data.
    2. Graphical helps in apportioning time in construction.
    3. Graphical progress-of-work record.
    4. Graphing an organization.
    5. A "line and staff" organization for shoe factory, brick works, ice plant, publishing house, department store, builder, or other Columbia large industry.
    6. A "functional organization" for the preceding.
    7. Authority and Responsibility:—inter-relationships and delimitation.
    8. Philosophy of works management.
    9. Organization by functional committees. Example: (1) Finance; (2) accounts; (3) information and statistics; (4) factory; (5) labor; (6) sales; (7) new development.
    10. Division of a foreman's duties into functions, to be allotted to as many "functionalized foremen."
    11. Operative economy and frequency of turning-over the capital.
    12. "Dumping."
    13. Sales.
    14. Applications of the "exception principle" in management.
    15. How frequently should various classes of statistics be graphed?
    16. Unnecessary statistics.
    17. Logarithmic cross-section paper in graphing statistics.
    18. Analysis of cost-keeping systems.
    19. Analysis and monograph on "fixed charges."
    20. System of distributing "burden" or "overhead charges."
    21. Comparison of wage systems, especially by curves and the analysis of the curves.

22. The theory of the "time ticket" in obtaining labor costs.
23. Costs of constructing a certain article, or a detailed part of an article.
24. Analysis of cost of a kilowatt-hour of electrical energy.
25. Influence of variations in the factors of kilowatt-hour cost.
26. Valuation of engineering properties.
27. Inventory of machines, cost, age, depreciation.
28. Influence of interest rates upon improvements.
29. The efficiency fraction in terms of labor-hours.
30. In a given establishment, what work can be removed to a "planning department."
31. A classification system for recording and for making usable the results of time studies in later planning-department work. (Tabor Mfg. Co.).
32. Analysis of the variables of (1) worker; (2) surroundings; (3) materials; (4) equipment; (5) tools; (6) motions, per Gilbreth's "Motion Study."
33. Planning the complete outfit and tools for some operations or "task."
34. Rearrangement of machines to secure better routing of work.
35. Making an "instruction sheet" for some operation, including time for each element.
36. The proper elements in an analysis of an operation.
37. Efficiency studies of university building operations.
38. Analysis of setting-up work in a machine.
39. Experimental time records on work.
40. Determining time and cost for (*a*) handling the raw material, (*b*) setting up the work in the machine, (*c*) machining, (*d*), removing the finished product, (*e*) making machine ready.
41. The care of materials; (*a*) design, (*b*) specification, (*c*) tender, (*d*) selection, (*e*) test, (*f*) custody, (*g*) use, (*h*) inspection.
42. The value of materials.
43. Equipment and personnel analyzed like materials.
44. Standardization of implements.
45. Standardization of methods.
46. Convenient locations of tools at a machine.
47. The care of tools, inside and outside of tool room, messenger service.
48. The design of a move-order system.
49. Works transportation; costs while in motion *vs.* of loading and unloading.
50. A system of classification numbers on shop orders. (Ennis, p. 30).
51. Cutting metals; tests of speeds, tool shapes, steels.

52. Development of a science of some trade or occupation, simple enough to be completed in time available.
53. Time and motion studies of any sort of occupation, trade, labor, business, profession,—existing in Columbia.
54. Efficiency study of sweeping, and of brooms.
55. Moving-picture studies of work.
56. Fatigue studies.
57. Most efficient size or weight of unit moved.
58. Necessary proportions of time for rest and work in various occupations.
59. Experimental psychology in the placing and selection of workmen. (Hugo Münsterberg's "Psychology and Industrial Efficiency").
60. Finding one waste, and tracing all its causes.
61. Observing, recording, analyzing and comparing any train of antecedent-consequent facts.
62. The influence of wrong units of comparison, when attempting to measure the comparative efficiences, methods, departments, officers, plants, etc.
63. Stores.
64. Topics relating to engineering education, industrial education, trade schools, apprentices, education of employees, organized labor, organized capital, unorganized public, governmental oversight and control.
65. New Zealand practice in the relationships of labor, capital and the public.
66. Recent industrial legislation.
67. (See 18 for locomotive coal-premium system).

32. Maintenance and Depreciation of Plant and Equipment.
1. Curve of depreciation of a given machine, exclusive of "getting out of date" or "obsolescence."
2. Curve of future depreciation of a given machine solely due to the past history of progress in methods of doing the work that this given machine is doing now.
3. Depreciation of power plant equipment.
4. Monograph on the science of depreciation.
5. Inspection of equipment.
6. Applications of the principle of "prevention of breakdowns."
7. Breakdown insurance *vs.* interest, depreciation, and obsolescence of duplicate idle equipment.
8. A study of depreciation of machine classes, (*a*) time and the elements, (*b*) wear in service, (*c*) obsolescence.
9. Causes for annual revisions of probable life.
10. Depreciation and betterments in replacement.

11. (See 31 for prevention of breakdowns).
12. (See 18 for depreciation of railway equipment).

33. Relations with Architects.
34. Relations with Metallurgists.
35. Relations with Civil Engineers.
    Coöperation with a C.E. student in the production of a joint thesis, as in cement, excavation and dredging, water power, industrial buildings.
36. Relations with Mining Engineers.
37. Relations with Chemical Engineers.
    Coöperation with a Ch.E. student in the production of a joint thesis, as in cement.
38. Relation with Electrical Engineers.
    Coöperation with an E.E. student in the production of a joint thesis; the E.E. handling the electrical side and the M.E. handling the mechanical side.

5. Thesis Subjects from Another Engineering School.

1. Application of Steam Engine Indicator to a Locomotive.
2. An Experimental Study of the Balancing of the Action of the Reciprocating Parts of a Locomotive.
3. Action of Reciprocating Parts on the Crank Pin Pressures of Certain Engines.
4. The Slipping and Friction of Oak-tanned Leather Belts. Strength and Elasticity of Shafting under Combined Twisting and Bending.
5. Design for a Hot Forge Nut Press, with Experiments on the Shearing Strength of Hot Iron.
6. An Experimental Study of the Surface Condenser.
7. Pressure on Lathe and Planer Tools.
8. Transmission of Power by Rope Gearing.
9. Design for Arrangement of Machinery in a Worsted Mill.
10. Experimental Investigation of Flow of Steam Through a Tube.
11. Errors of the Steam Engine Indicator.
12. Tests on Pumping Engines with Reference to Cylinder Condensation.
13. Design for a Mine Hoisting Plant.
14. Experiment on the Steam Injector and Apparatus for Determination of Velocity of Delivered Water.
15. Tests of the Strength and Other Properties of Rope.
16. Experimental Investigation of Proper Angles for Cutting Tools.
17. Experiments on Strength of Pulleys, Keys, and Set Screws.
18. Experiments on the Performance of a Windmill.
19. Experimental Study of the Deflections of Parallel Rods at Different Speeds.

20. Strength of Eyes as used in Boiler Stays.
21. Experiments on Strength of Cast Iron Gear Teeth.
22. Tests on Tensile Strength and Modulus of Elasticity of Hard Drawn Copper Wire
23. Experimental Investigation of Friction and Breaking Strength of U. S. Standard Bolts and Nuts.
24. Design for a Pneumatic Holding Machine for Car Wheels.
25. Experimental Investigation of Slip of Leather Belts on Cast Iron Pulleys.
26. Tests on Lift and Discharge of a Safety Valve.
27. Design for an Automatic Rack Cutter, including Some Tests on Milling Cutters.
28. The Design, Construction and Testing of a Torsion Dynamometer.
29. Experiments to Determine Effect of Repeated Bending on Wrought Iron and Steel.
30. Design of the Reciprocating Parts and Valve Motion of a Special Form of Compound Engine.
31. Experimental Determination of the Modulus of Elasticity of the Skin of Cast Iron Beams.
32. Tests on a "Sturtevant" Steam Hot Blast Apparatus.
33. Experiments to Determine the Amount of Moisture that Steam will carry.
34. Experiments on Friction of Bolt Threads.
35. Explosion of Gases in a Closed Vessel.
36. Experiments on the Value of the Steam Jacket on a Direct-Acting Pumping Engine.
37. Tests on Elevators.
38. Tests upon Flange Coupling under Repeated Stresses.
39. Investigation of the Action of Steam Separators.
40. Experiments to Determine the Coefficient of Discharge from Pipes through Branches and Side Orifices. (Cooling tower?)
41. The Distribution of the Pressure Exerted by Cast-iron Spring Piston Rings.
42. Tests on the Bursting Strength of Steam Pipe Fittings.
43. Location and Effect of Blowholes in Steel Boiler Plate Rolled from Bottom Poured Ingots.
44. Design for a Boiler Shop.
45. Experimental Investigation of the Action of a Steam Engine Governor.
46. Friction Theory of Belting.
47. Automatic *vs.* Hand Stoking on a Galloway Boiler.
48. Shaft Coupling.
49. Strength of Telegraph Wires under Different Conditions.
50. Experiments on Shearing Strength of Cast Iron.
51. Errors in the Cards of the Steam Engine Indicator due to the Length and Size of the Pipe Connections used therewith.

52. Design for a Rock Crusher.
53. Tests on an Evaporative Surface Condenser.
54. Action of a Steam Rock Drill under Varying Pressures.
55. Tests of Tensile Strength and Elasticity of Malleable Iron.
56. Effect of Jackets on a Simple Engine.
57. Determination of the Pressure Required to Form Belt Heads.
58. Determination of the Variation in the Density of Steel under Stress.
59. Study of the Frictional Resistance of Shafting.
60. Investigation of the Stress in Cast-iron Pulley Arms and Rims.
61. Experimental Investigation of the Distribution of Power in a Modern Newspaper Plant.
62. Action of Wind Pressure on Surfaces.
63. Tests on Various Types of Steam Reducing Valves.
64. Experimental Study of the Application of Compressed Air to Shop Uses.
65. Variation of Coefficient of Friction between Leather Belting and Cast Iron at Different Speeds of Slip.
66. Loss of Pressure of Air Flowing Through Small Pipes.
67. Investigation of the Distribution of Power in a Cotton Mill, and a Study of Resulting Losses in Transmission.
68. Wear of Brake Shoes of Different Materials Relatively to the Wear on the Wheel Tires.
69. "Slip" and "Creep" of Leather Belting.
70. Experimental Investigation of the Action of the Pendulum Governor.
71. Experiments in Hardening and Tempering Steel.
72. Fly-Wheel Calculations.
73. Relative Efficiency of Bearings and Lubricants of a Spinning Frame under Mill Conditions.
74. Design of a Central Heating Plant.
75. Design of an Oil Machine.
76. Comparative Strength of Standard Screws and Cylindrical Rods of the same Root Diameter.
77. Design of a Locomotive Repair and Erecting Shop.
78. Effect of Different Initial Pressures on Explosive Mixtures of Gas and Air.
79. Relation between Draft and Temperature in Chimneys.
80. Friction of Steam in Elbows and Bends.
81. Tests of the Heating and Ventilating Plant of a Theatre, combined with a Design for a System of Ventilation of an Office Building.
82. A Study and Design of Steam Meters.
83. Design of an Experimental Yarn Tester.
84. Effect of Heating, Quenching in Oil, and Subsequent Annealing, on the Physical Properties and Microstructures of Steel Castings.
85. Tests on Heating Cars by Steam from the Locomotive.

86. A Method of Testing a Pneumatic Chipping Hammer.
87. Tests of a Simple and of a Compound Traction Engine.
88. Oil Separators.
89. Tests on Air Filters.

6. Thesis in Electrical Engineering.

TOPICS SUGGESTED.

1. GENERAL.
   1. Choice of Frequency.
   2. Pure Sine Waves.
   3. Effects of Distorted Waves.
   4. Magnetic Circuits of Various Forms and Dimensions.
   5. Distribution of Flux in D. C. and A. C. Circuits.
   6. Sparking; Its Causes and Effects.
   7. Effects of Alternating Current upon Reinforced Concrete.
   8. Investigation of the Laws of Friction.
   9. The Cost of Power.
   10. Selection and Arrangement of Useful Data.
   11. Study of Plants at Coal Mines.
   12. Study of Very Small Hydro-Electric Plants.
   13. Gyroscopic Balancing.
   14. Magnetic Losses in Iron.
   15. On the Law of Eddy Currents.
2. MEASUREMENTS.
   1. Instrument Transformers.
   2. Transformer for Measuring Large Currents.
   3. Electrical Methods of Measuring Speed.
   4. Slip Meters.
   5. Accelerometers.
   6. Methods of Taking Alternating Current Waves.
   7. Resonance Analysis.
   8. Phase Measurements.
   9. Investigation of Induction Type Meters.
   10 Measurement of High Voltages.
   11. Ampere Hour Meters.
   12. Absorption Dynamometers.
3. MATERIALS.
   1. Commercial Methods of Testing Iron.
   2. Magnetic Method of Testing for Imperfections in Iron.
   3. Tests on Insulating Materials.
   4. Heat Conductivity of Insulating Materials.
   5. Study of Wire Voltage Insulators.
   6. Formation of Copper Compound on Surface to serve for Insulation.
4. GENERATION.
   1. Comparison of Prime Movers.
   2. Contact Resistance.
   3. Commutation of Direct and Alternating Currents.

4. Heating of Coils.
5. Do Cross Turns have Demagnetizing Effect?
6. Prevention of Hunting.
7. Study of Efficiencies and Losses of Dynamos
8. Regulation of Synchronous Machines.
9. Effects of varying Voltage upon the Operation of Induction Motors.
10. Compounding Generating Station.
11. Design of Electric Plant for the University of Missouri.

5. TRANSFORMATION.

1. Experimental Tests of Transformer Theories.
2. Theory of Straight Core Ferric Inductances.
3. Multiphase Transformer Connections.
4. Effects of Residual Magnetism upon the Exciting Current of Transformers.
5. Transformation of Phase.
6. Direct Current Balances.
7. Study of Rectifiers.
8. Study of Boosters and Batteries.

6. TRANSMISSION AND DISTRIBUTION.

1. Systems of Electrical Distribution.
2. Design of a Distribution System.
3. The Edison Three-Wire System.
4. Network Design.
5. Comparison of Methods for Regulation of Voltage.
6. Design of an Automatic Voltage Regulator.
7. Automatic Transformer Switch.
8. Construction of a Phase Regulator.
9. Design of Transmission Lines.
10. Power Transmission by Direct Currents.
11. Protection of Overhead Lines.
12. Installation of Cables.
13. Fire-proof Wiring and Switchboard Construction.
14. Grounding the Neutral.
15. Analysis of Losses in a System.

7. UTILIZATION.

1. The Application of Motors.
2. Use of the Series Alternating Current Motor for the Electric Drive.
3. Power Required by Various Machines.
4. Comparison of Different Electric Lights.
5. Study of Illumination.
6. Study of Lighting for Gymnasium.
7. Modification of Electric Candle for Alternating Currents.
8. Electric Furnaces.
9. Electric Forging and Welding.
10. Laboratory Heating Devices.
11. Use of Electricity in Mining.

8. Electric Railway Engineering.
   1. Choice of Types of Motors for Traction.
   2. Study of Train Motion.
   3. Study of Train Resistance.
   4. Alternating Current Motor.
   5. Regenerative Control.

Discussion.

Professor H. Wade Hibbard: I have presented this as one school's definite way of bringing to the attention of the students during the semester before they become last-year men the fact that a thesis is to be expected and that they should get ready for it by thinking about it during the semester and during the summer. They will thus be able to choose a definite subject within a month after they return to school in September, and to lay out their plans so carefully and read so extensively during the one credit-hour of the first semester that they will start actual work in a detailed and thorough fashion at the very beginning of the second. The number of credit-hours allowed for the thesis in the second semester of the last year is a minimum of two, that is, $\frac{2}{15}$ of the semester's work. The maximum has not yet been decided upon nor reached. We are feeling our way toward what may be the maximum. With the reorganization of the school of engineering, we include all courses given in mechanical engineering in our previous four-year course, while still allowing some twelve credit-hours of elective in the three-year course. I do not suppose that these hours will ever be used in the thesis. We are feeling our way toward what we hope is going to be an increasingly valuable portion of the mechanical engineering curriculum.

Professor J. J. Flather: The subject of thesis is one that has received careful attention here at the University of Minnesota. Last year an investigation was carried on by Professor Martenis, of the mechanical engineering department, to learn to what extent theses were required in the various institutions, and also how much credit is given for them. In the mechanical engineering department at the University of Minnesota we require no specific number of hours the first semester, but we do require essentially the same preliminary preparation for theses as is required by Professor Hibbard. All preparation

work must be done before the Christmas vacation, but the student heretofore has not had any credit for that work. He has been required to do his preliminary reading and planning so that by the time the Christmas vacation came round he was ready to do some work during that vacation. In the second semester we require three credit-hours, that is, we expect a student to put in at least six hours per week on his work during that semester. As a matter of fact the time spent invariably exceeds this amount. We merely give him credit in our curriculum for three hours out of a total of perhaps eighteen or twenty.

After the investigation above referred to the mechanical engineering department recommended that one hour credit per week be allowed for theses in the first semester, and that in the second semester a total of five credit-hours be spent upon the thesis and elective subjects combined. This is somewhat flexible and the five hours can be divided as required. This arrangement is valuable because it permits a student to elect a subject closely articulated with the thesis for which ordinarily credit could not be given in the thesis itself and yet it might have great utility to him.

It also permits a man to spend the full five credit-hours on the thesis if this should be thought advisable, and on the other hand, if the conditions should seem to indicate that a lesser amount of time on the thesis proper and a greater amount on some collateral subject should be the best arrangement, this would be permitted without his having to obtain special permission from the faculty.

In a great many cases too much time has been put in on thesis problems. A student is apt to think that the thesis is the principal thing in his senior year, and accordingly neglect his regular studies. He is very prone to "cut" this lecture or that recitation in favor of thesis work.

As a result of a study of the curricula of leading schools including such institutions as The Case School, Columbia University, Iowa State University, Lehigh University, the Massachusetts Institute of Technology, the University of Michigan, the University of Nebraska, the Ohio State University, Rose

Polytechnic Institute and the University of Wisconsin, the average credit for thesis work by the senior engineering students is known to be 3.55 hours. Electrical students were given 3.94, and mechanical students 3.25 semester credit-hours during the year. This shows that, after all, there is not the preponderance of hours spent on the thesis work formerly so spent.

Professor Hibbard: Will Professor Flather kindly interpret these figures for us? That is what portion of a student's total time per week is represented by the figures given?

Professor Flather: Those figures are based on sixteen or eighteen credit-hours per week. It should be understood in this connection that a number of institutions included do not require any specific time to be spent on thesis work. Columbia University, for instance, does not require it of "mechanicals," and for "electricals" it is optional. Certain students at Cornell University may take thesis work, if particularly qualified for research work. Then it is expected that they will, under the guidance of the head of the department concerned, select suitable theses subjects. In this case the student may spend four credit-hours on his thesis. For other men it is considered wiser to spend the time on some other study. At the University of Michigan the thesis is not required, so also at the University of Nebraska while thesis work is a part of the engineering curricula a student may elect some other subject, if deemed advisable by the department concerned. The thesis is not required at the Sheffield Scientific School in the three-year course, but in the five-year course ten hours are required. Professor Hibbard's suggestion of one credit-hour in the first semester with a minimum of two in the second is good, but I should limit the number of hours for fear that the thesis might be considered as unduly important. The undergraduate student should confine his attention rather to his study work because research work is not generally suitable for undergraduate students.

Dean Adolph Shane: The subject of the theses has been "bobbing up" for some time. Teachers of engineering are perplexed to determine whether or not such work is valuable. If the thesis is considered to mean only a subject for original

research study, then the value to the student may be considered doubtful.

Dean P. F. Walker: I wish to go on record as one who is still in favor of the thesis. I do not, however, care to see more than a total of three credit-hours, each representing three hours per week of actual work, the total time being divided between the first and second semester. There are two reasons why I believe very thoroughly in the thesis. In the first place it is one of the best methods by which we may teach the student to think for himself, to really think a problem through. For that reason the responsibility for the work should be thrown upon the student. Second, it is worth while for the student to have and preserve a record of one fully completed task or problem, one into which he has put his best thought and work, and one which will stand in the record as representing his own work.

From what I have said it follows that I believe that the thesis should be on a subject involving original investigation whenever that is possible. This kind of work often arouses the student to unusual effort and has a certain value in bringing him to a realization of his own powers and in enabling the instructor to gauge those powers.

Professor Hibbard: With regard to Professor Flather's proposed plan that the thesis and electives should be permitted in the first and second semester, I want to ask who decides how much time shall go into the thesis and how much into the elective, the student or some member of the faculty?

Professor Flather: Our practice is that it must be determined in consultation with the head of the department.

Professor Hibbard: Professor Flather represents a large number who believe that research is not suitable for undergraduates. Going back to my previous remarks I would repeat that by having, as we now do, two years work in the college of arts and sciences, and three years in engineering we gain twelve credit-hours, that is, $^{12}/_{15}$ of one semester for additional work. With the help of the large number of manual-training high schools which are doing excellent shopwork we shall gain at least eight more. In other words, our new curriculum in mechanical and other branches of engineering

will make the last-year men more mature than the seniors whom we had under the four-year course. They are by $^{12}/_{30}$ or $^{20}/_{30}$ of a year nearer to being what might be called graduate engineering students.

In the atmosphere of post-high school training, they will have had four years before their last year. Furthermore, such a last year is of as much greater value than a master of arts' year, as any engineering course is of greater research educational value than the usual four years' Arts course of American colleges.

I want to urge farther that the thesis subject should be a small one. A mistake is made when some vast problem like designing a power plant for the Twin City railway, or an important test of a plant is attacked. Possibly the reason for a student's taking too large a subject has been the absence of such a list of suggested topics as I have been asked to furnish in connection with this paper, a list of 1,500 topics. If you make use of this list with your students next year you will find some things put down in a very minute fashion, minute portions of large subjects.

Professor Shane said that the choice of a subject should be left to the student. I don't suppose he meant by that that the student could actually choose his subject irrespective of what the professors think he ought to do?

One of the speakers suggested that research work does not amount to much. You will notice that I read: "Let the student so plan the work that he may hope that his results will be accepted and paid for and published by an engineering paper." We have already had some of that recognition at Missouri. I submit that, if an engineering journal in good standing will pay for and devote several pages to the results of a thesis investigation, that research has value to the profession.

Dean Shane: No, that was not my idea. The work should be always subject to the approval of the head of the department. I merely make the point that the student is more interested in a subject of his own choosing.

Professor Hibbard: I agree with you decidedly.